ILLUMINATING ENGINEERING

JUNE 1952

◆

Featuring

Home Lighting

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

CORRECTION!

For years we and others have been publishing coefficient of utilization tables which grossly underrated the STAR. We have suspected for some time that our tables were low, but not until the completion of special studies by our illuminating engineers did we realize that *we have actually been underrating the STAR up to 40%*. It is time to set the record straight.

By using the interflection method new tables have been calculated which, as shown by actual tests of existing STAR installations, closely approach the performance of the STAR. These tables given below have been published in our recent Catalog 50-B, a copy of which will be sent you on request. Note that the room factor is different from that used in the old tables.

The new tables show an average error of 5% low. The old tables were found to be 30 to 40% low. The STAR has not been redesigned. It is the same as it has always been. The big difference is that fewer units are required to light a given room area at a given level than has heretofore been thought necessary. This is extremely important, since it means that installations of this superior luminous-indirect fluorescent luminaire will compare more favorably in cost with installations of direct-indirect open-bottom louvered units. We show below an example of the per-luminaire saving possible.

NEW COEFFICIENT OF UTILIZATION TABLES FOR THE STAR

MF=.75
63-1½%
7-½%

$$\text{Room Factor} = \frac{\text{Ceiling Height}}{2} \left\{ \frac{\text{Length} + \text{Width}}{\text{Length} \times \text{Width}} \right\}$$

Ceiling	80%			70%	
Floor	30%			30%	
Side Walls	65%	50%	30%	50%	30%
Room Factor					
0.1	.68	.63	.62	.55	.53
0.2	.62	.57	.53	.49	.45
0.3	.57	.51	.45	.43	.39
0.4	.52	.45	.39	.39	.34
0.5	.48	.40	.34	.34	.29
0.7	.41	.32	.26	.27	.23
1.0	.32	.23	.18	.20	.15
2.0	.14	.08	.05	.07	.04
Floor	10%			10%	
0.1	.58	.56	.54	.48	.47
0.2	.54	.51	.48	.44	.41
0.3	.50	.46	.42	.40	.36
0.4	.47	.42	.37	.36	.32
0.5	.44	.38	.33	.32	.28
0.7	.38	.31	.25	.27	.22
1.0	.30	.22	.17	.19	.15
2.0	.14	.08	.05	.07	.04

TESTS OF EXISTING STAR INSTALLATIONS AGAINST THE NEW TABLES

Existing Installation	Kr	Calculated Footcandles	Measured Footcandles	% Error
Classroom	.42	31.7	33.5	5%
Classroom	.53	39.0	40.0	2%
Classroom	.39	20.8	23.4	11%
Classroom	.68	42.4	45.0	6%
Classroom	.68	28.3	29.1	3%
Office	.61	38.3	38.5	1%
Electrical Power Laboratory	.12	42.5	45.5	7%

To produce 40 footcandles initially in a room 22′ x 34′ x 12′. Ceiling 80%, side walls 50%, floor 15%. Using two 40W standard cool white lamps per unit.

Old tables: 21 STAR units indicated.

New tables: 16 STAR units indicated.

The F. W. Wakefield Brass Company

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To help illuminating engineers to *know* the latest answer to this perennial question, I.E.S. regional Sections and Chapters held 391 local meetings last year. Their prime purpose was to keep members informed of the ever-changing tools with which they practice their profession.

The scheduled presentations and informal discussion at these meetings contribute to achievement of the Society's dual objective—"advancement and *dissemination* of knowledge of the art and science of illumination."

Illuminating Engineering Society

1860 Broadway, New York 23, New York

ILLUMINATING ENGINEERING

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

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Views and Opinions

Basic Education In Illuminating Engineering

Its relation to the recognition of illuminating specialists as registered professional engineers

THERE ARE only a few colleges which offer a basic course in Illuminating Engineering conducted on a high technical level. The result is that most graduates do not qualify as Lighting Application Engineers, nor do they have basic knowledge of photometry, photocell characteristics, etc., which finds application in many other fields of engineering. These are, however, the men who sometimes qualify as electrical engineers for a professional engineering license, and may thus practice Illuminating Engineering, possibly with adverse results.

ON THE OTHER HAND, practical lighting experts frequently have difficulty in qualifying as Registered Professional Engineers, except in those few states where they can obtain specific registration as Illuminating Engineers.

IT IS my feeling that, in order to approach the goal of professional registration of Illuminating Engineers, serious attention should be given to the basic education in this field, on an advanced technical level.

LET US FIRST examine where such a basic course in Illuminating Engineering fits in a college curriculum. To be specific, let us consider some features of the usual curriculum offered. As a rule, there is a basic course in experimental and analytical physics—an excellent modern text is Lemon and Ference *Analytical Experimental Physics*, University of Chicago Press, offered in the sophomore year. The following table shows how the commonly used subdivisions of such a physics course correspond to the various branches of engineering training, enabling the student to progress from essentially qualitative knowledge to quantitative mastery of the basic elements:

Mechanics	Applied Mechanics
Heat	Engineering Thermodynamics
Sound	Engineering Acoustics
Electricity and Magnetism	Electric Circuit and Field-Theory
Light and Optics	Illuminating Engineering

FROM the above, it is clear that without training in Illuminating Engineering the curriculum would have an obvious defect. It is also apparent that a basic course in *Illuminating Engineering* should be broader than *Lighting Applications*. It should train one in the principles of light measurements on which the definitions of photometric quantities are based. This fundamental knowledge should enable the student to appreciate and discuss the problems of automotive lighting, aircraft lighting, design of optical and photometric measuring equipment and to work with lighting installations.

IT WOULD be quite useless to present a course of the above described type of architects. For these, the course in Lighting Design should devote most time to laboratory in a model room where walls and fixtures can be changed, and to work on smaller models. The remainder of such a course could be spent on basic definitions of photometric quantities, elements of vision, and lighting computations.

AT FIRST, the above described course for electrical engineering majors sounds like a fair description of a series of advanced courses in Illumination and applied Optics. My experience, however, has been that it is possible to offer on a senior (or junior) level a single basic course in Illuminating Engineering which would cover all of the essential features described above. Students who have successfully completed such a course were able to assist me in the development of some photometric equipment and were also able to enjoy lectures on fairly advanced topics.

THE CHIEF difficulty in having a course of the above type offered in an Electrical Engineering department is that the majority of its faculty is not sufficiently familiar with the subject to really enjoy teaching it. The only remedy that I can recommend in this situation is to have more highly technical lectures with demonstrations delivered at various schools under the auspices of engineering societies, the Physics Department, Engineers' Club, Sigma Xi, etc. Such a program of lectures would be of interest to the I.E.S. as well as to the manufacturers. Continued efforts in this direction should also lead to wider student interest and student membership in the I.E.S.

THE DEVELOPMENT of high technical level courses in Illuminating Engineering in colleges, to-

gether with series of lectures by invited speakers, would effectively raise the general level of information on this subject. This in turn would create greater interest in and appreciation of this field of engineering science, resulting ultimately in wider professional recognition by other engineering groups, not merely as an art but as a branch of engineering.

THE AUTHOR believes that, unless serious steps are taken in the near future to implement the above suggested educational program, courses in Illuminating Engineering will disappear from the ranks of required courses in electrical engineering curricula of progressive colleges. All that will then remain will be lighting application courses for architects, and the advanced research in physical optics. A large gap between these two fields of activity would exist, and there will be no one trained to fill the gap. This prediction, however glum it may appear, deals with reality; the author has observed that some of these trends are already in evidence.

G. S. TIMOSHENKO, *Professor and Head of Department of Electrical Engineering University of Connecticut*

Unity in Engineering

IN THE INTERESTS of real unity in the engineering profession I would like to submit the following thoughts for consideration.

I HAVE BEEN a member through all grades, and continuously since college, of one of our larger technical societies. I have also been a state section president and contributed to committees and publications. It should be evident then that I am not interested in sabotaging the value of our technical societies.

HOWEVER, to many of us, the crying need for engineers today is one paramount society that will truly represent all qualified engineers both professionally and technically at local, national and international levels. It should be an integrated society, and not merely a banding together of existing societies into a federation which neither represents all qualified engineers nor permits direct and democratic election of officers and directors by the individual members.

MANY of us in the grass roots are disappointed in the four unity plans (A, B, C, D) so far proposed and would like to see at least one other plan considered. We are also disappointed that the individual members have had little or no opportunity to study all plans, compromises or worthy minority ideas.

APPARENTLY the Exploratory Group in its report of December 1950 expected individual members to have ample opportunity to express their ideas on unity. This does not seem to have been done generally and many of us feel that we are being forced to consider plans that could be improved for the benefit of engineers. I have written the Exploratory Group on this and suggested that each individual member of at least the fifteen national societies that make up the Exploratory Group be polled to learn his wishes after he has had ample opportunity to study all plans, compromises and worthy minority ideas. Among the latter there is an admirable plan (called Plan E) that has been submitted by the Florida Section of American Society of Civil Engineers. Unless engineers can be sure of what they want there will always be dissatisfaction and disunity.

AT A VERY recent regional meeting of the American Society for Engineering Education, at which I spoke on the unity situation, I was surprised to learn of the vital interest this large group of engineering educators had in the subject; of their almost unanimous dissatisfaction with the Plans A, B, C and D; and their desire for more information and a better integrated plan to consider. A resolution was passed unanimously to that effect and forwarded to the national A.S.E.E. secretary. It turned out that only five out of the group had seen or heard much about the four plans before my talk. They were also keenly interested in having a plan that would be a real integration of technical and professional interests and one in which the individual could vote directly for its officers and directors.

I AM interested in real unity and not further disunity. I intend to support wholeheartedly any plan that the majority of engineers favor. Some of us want to be sure, however, that engineers have adequate opportunity to express their wishes on the plan they want. Such can hardly be done without a poll, or if they are told it must be one of the four plans or nothing.

T. H. EVANS, *Dean of Engineering Colorado Agricultural and Mechanical College*

Indoor-Outdoor Living

BY NIGHT AS WELL AS BY DAY — Architectural planning and engineered control of both natural and artificial light provide a luminous environment which brings indoors, visually, much of the outdoors, to be enjoyed both by night and by day.

By KENNETH C. WELCH

IN OUR CLIMATE (Grand Rapids, Michigan) we spend an overwhelming part of our existence indoors, to the extent that I believe the interior looking-out viewpoint in a home is 90 per cent important as compared with exterior appearance. And I have always felt that good contemporary design could produce a much more satisfactory interior-exterior relationship. Enclosure has become a filter between exterior and interior environments and from this viewpoint a house becomes something more than shelter from the elements.

One of the new architectural concepts of housing is the technology which has permitted glass walls making the exterior view a part of the interior. This has worked very well in daylight hours, but with vertical glass surfaces and conventional methods of lighting it has not succeeded at night.

In designing the luminous environment of my own home, the desire was to bring, visually, as much of the interesting outdoors as possible into the interior at night as well as by day. Even with very modern design and large glass surfaces, this can be completely lost at night — the only time most of us (particularly us males) can enjoy this interior-exterior treatment. In the design of this house, it was my aim to produce a geometrical distribution of enclosure, with engineered control of both daylight and night-time brightnesses, which would permit the enjoyment at night-time of the pleasing exterior private view, with a planned informality of landscape.

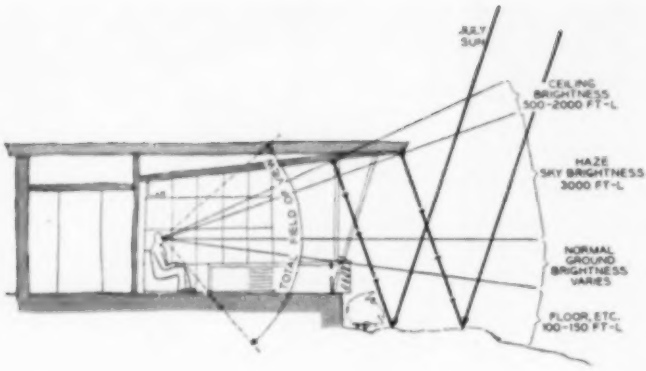
Author: Architect, Grand Rapids Store Equipment Co., Grand Rapids, Mich.

Sky Brightness Control

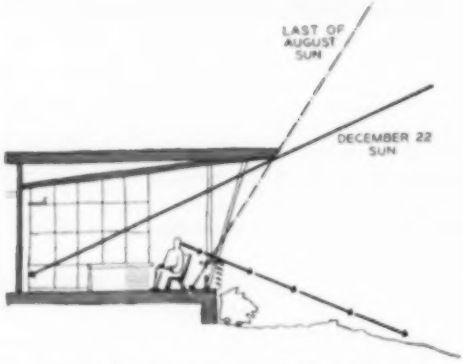
In daytime, not only is the exterior view brought indoors, but by means of unusual controls, brightnesses of the sloping ceiling are held as close to that of the sky as possible. The slope of the ceiling and planting beneath the window sill both figure in the technique.

The main feature of the house is an insulated glass wall with a 28-inch-high sill, with about eight feet of glass above this for the whole 62-foot length of the south facade. The ceiling slopes from the bottom of a cove 8 feet high upward and outward to a height of 10 feet at the glass wall. Valances and spandrels are eliminated and, accordingly, the sloping ceiling picks up a component of sky light,

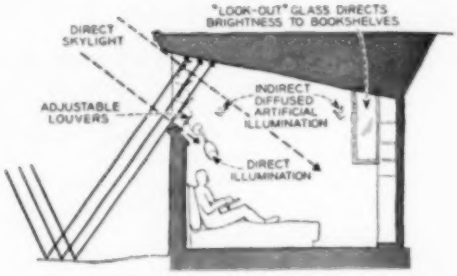
By Day . . .



The brightness of the immediate landscape determines the interior daylighting control through ceiling reflectance. Direct sunlight does not enter the room from April through August.



Brightness is reflected to the ceiling but is shielded from normal viewpoints in the room.



North bedroom windows are designed for light only. Sills are 6 feet high, affording privacy.

materially increasing the overhead interior brightness in the daytime.

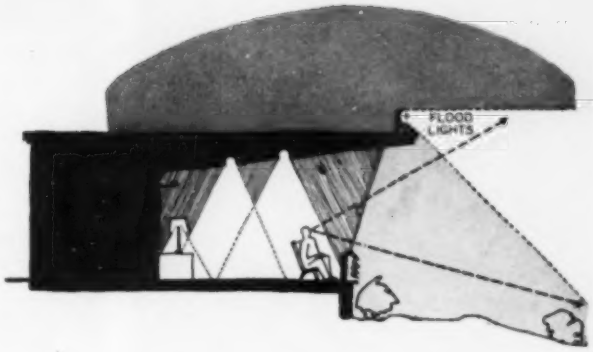
The south rooms are kitchen, combination dining, music and living room and a separate main bedroom, all with the sloping ceiling. This sloping ceiling, continuing outward and upward as the solar control overhang, gives a feeling of unlimited spaciousness. The living room, 14 feet wide between the book wall and sill, seemingly extends, when draperies are open, 100 feet down the hill where the large trees begin. The glass area in the main south rooms is over 50 per cent of the floor area.

The cold room, servant's suite, storage passage and combination sleeping room-study or guest room are on the north side. There is no glass on the west wall and only one small "look out" panel in the east wall. The two glass panels from wall to wall and to the sloping ceilings, in the servant's room and study-bedroom, have 6-foot-high sills. This affords privacy, the high-silled windows being designed for light only.

Another concept was that exterior glass areas should be for light or light and view, not for ventilation. Hence, all glass is fixed and air is taken in through weather-proof louvers with filters below the sills or in exterior walls. These openings were kept small and weather-tight, and any possible infiltration is controlled. The house can be almost hermetically sealed, when this is desirable.

Direct sunlight never enters the room from April through August. Sky brightnesses during this period may reach a peak of 3000 footlamberts. The reflected light from the planting, etc., brings ceiling brightnesses up to about 2000 footlamberts, an almost 1 to 1.5 ratio.

and at Night

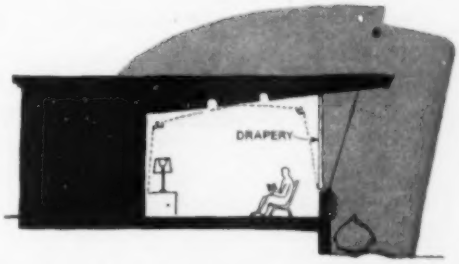


Downlights indoors give a level of 3-5 ft-c. Floodlights mounted on roof highlight trees and shrubbery (see photo). With brightnesses indoors and outdoors about balanced, the exterior view becomes a part of the living environment.

Window Control

With the tools and materials which modern industry has given us, it seems to me it should be possible to create easily a completely glass wall or change it to a draped wall, or shield at will any portion desired. We should be able to adjust louvers and draperies to any desired point to control brightness and spatial environment. Draperies in most homes have become primarily a decoration. More often they keep light out rather than functionally control it.

In this house, draperies provide an interesting decorative effect, but this was only incidental. Their first functions are, when drawn, to insulate the glass wall and to provide shielding where required. The draperies are individually controlled in such a manner that they may be pulled around to the side walls, leaving the glass wall fully exposed; or sections may be pulled to whatever portion of the window it is desired to shield. There are no spandrels or valances, since these would introduce patches of low-brightness, perhaps 10 to 20 footlamberts, into the direct line of vision, and spoil the carefully engineered brightness ratios.



Draperies can be drawn to cover the whole window wall or any part of it, if so desired. They are individually controlled for maximum convenience in adjusting.

Night-time Control

As can be seen in the photos, the night-time technique, from the standpoint of brightness ratios, makes a completely reversed picture with the trees bright against the dark sky. Combined with the great seasonal changes we have in Michigan, this makes for a great variety of exterior-interior appearance. Life is never environmentally monotonous in a truly functional modern home.

Downlighting — standard Alzac reflectors with standard I. F. 15-watt lamps with a 45-degree cut-off — has been used in the living room, recessed in the ceiling and shielded on the window side to avoid reflections. The aperture of the downlights is 5¼ inches and about five footcandles of general lighting is provided for "social lighting," namely conversation, eating and music.

Portable lamps, largely decorative, are closed at the top, recommended practice notwithstanding, so that they do not produce any brightness on the ceiling. Such bright patches on the ceiling would be reflected in the sloping glass wall, causing veiling glare and fogging the exterior view.

This is important, since the exterior view is "brought indoors" at night also. A battery of twelve PAR-38 150-watt floodlights and spots are mounted on the roof to illuminate the outdoor area. Brightnesses are balanced with those indoors, so that by a reversal of the daylight technique, interior-exterior living is extended to the evening hours, in all seasons.

Light from a 40-watt fluorescent lamp in a recessed, glass shielded luminaire is reflected by the white door and plaster wings, illuminating steps and entrance.

A variety of reflector designs for two-lamp 20-, 25-, or 40-watt tubes provide fluorescent lighting for the home workshop, laundry and other utility areas.

Fashions in Fluorescent

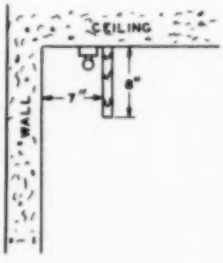
By MYRTLE FAHSBENDER

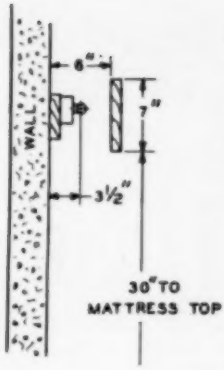
"CAN IT BE used in the home?" That query was made in the first sentence of a study on residential fluorescent lamp applications published in ILLUMINATING ENGINEERING in September 1940. Twelve years later, the answer is an unequivocal *yes!*

The increase in fluorescent lamp life and efficiency, the improvement in colors, and the additional sizes and shapes of fluorescent sources since 1940 have been contributing factors in the growing acceptance of fluorescent lighting. The greatest impetus, however, to the accelerated acceptance of fluorescent lighting in the home has been: (1) better and less ornate luminaire styling, (2) luminaires created for a variety of locations and seeing conditions, (3) the use of plastic and glass diffusing media for shielding, and (4) the decorative fashion

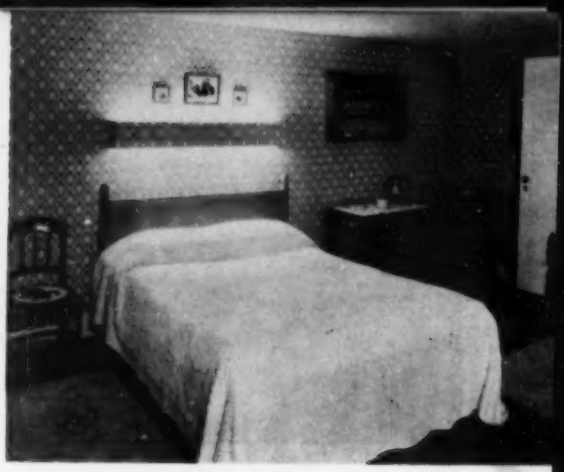
Director of Residential Lighting, Westinghouse Electric Corp., Bloomfield, New Jersey.

Cornice lighting around three walls and a slimline lamp concealed across the bookcase adds a decorative and distinctive air to this living-dining room. Portable lamp and pin-hole downlighting over the table are from incandescent sources.





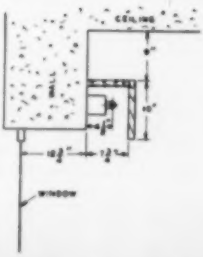
A 40-watt lamp for a double bed, or a 25-watt for a single bed properly installed on the wall behind a valance board provides comfortable light for reading in bed.

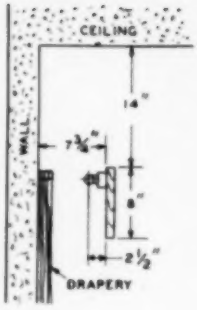


In remodeling, the pantry and the kitchen became one — linked by continuous counter space and fluorescent lighting behind twin window valance sections.

Fluorescent lighting for decorative accent! Tubes under the mantel shelf give emphasis to the summer foliage, andirons and panelling, while the graceful pediment atop the breakfront is silhouetted against the glow of a single fluorescent tube.

The bay-picture window at night continues to be a center of interest because of the luminous effect from the glass curtains created by a slimline tube mounted on the wall. The rather dark wall and limited distance from the top of the valance to the ceiling—nine inches—necessitates a closed top valance.





Lighting to enhance the color, pattern and texture of wall area and drapery is produced by a wall-to-wall valance. Two 72" slimlines (end-to-end) may be lighted independently to create variety of effect. The installation shown is balanced by an identical valance across a large window at the opposite end of the room, and both are supplemented by incandescent lamps in portables.

created for slender lines of light from coves, cornices and valances.

Since 1940, lighting specialists have become more cognizant of the fact that a great many of the working areas and decorative features in the home are lineal in character. It is not surprising to find fluorescent lamps actively used over the sink and work-bench, at each side of a mirror, under kitchen cabinets, in coves, and behind valance and cornice boards for continuous lighting effects.

Many have come to accept the one-hundred-per cent-fluorescent-lighted kitchen, utility room and bathroom. The majority of homemakers, however, continue to desire a combination of incandescent and fluorescent lighting in the living room, dining room, and bedroom.

In 1952, we no longer question whether the fluorescent lamp can be used in the home. It is being used. Twelve years' experience has proved the fluorescent lamp to have advantages over any other light source in certain locations and for the attainment of certain desired effects. On these pages is a diversified collection of pictorial proof that fashions in fluorescent are popular from the entrance to the work-bench, for lighting that is utilitarian or decorative.

All light sources shielded by attractive glass for greatest eye comfort. One 32-watt and one 22-watt circular fluorescent tubes in the ceiling unit combine with 15-watt tubes at the mirror for general and local lighting.

Lines of fluorescent lighting from shielded ceiling and wall units are placed to provide general and local illumination. On the ceiling opposite the windows, an identical unit (two 25-watt tubes) is located over the refrigerator work area. *Photo courtesy Parents' Magazine.*

Living Room Relighting With Applied Structural Forms

By AILEEN M. PAGE

The relighting of this living room was first-place winner of the 1951 contest conducted by the Cleveland Section of I.E.S. for "My Most Interesting Lighting Installation.

WHEN THE OWNERS of the home described here embarked on a program of improving the appearance and comfort of their recently-acquired home, like many other couples they were entirely unaware of the major contribution that good, up-to-date lighting would make in its living comfort, convenience and appearance. They had completed major repairs and redecoration in the dining room without any thought of replacing the old "eyesore" type of bare-bulb lighting fixture. Later on, a lighting counselor finally convinced them that a comparatively small investment in lighting equipment would pay large dividends in enhancing their enjoyment of the redecorating investment. The results were far beyond their expectations. They could not imagine that one modest two-lighting-effect luminaire and one fluorescent channel placed in a window niche (see Fig. 2) could accomplish such wonders.

A few months later, it was time to think about redecorating the living room. Because of the dining room experience, this time advice was sought *early* in the planning. This 14′ x 18′ living room presented architectural as well as lighting problems. It had a framed 18″ x 24″ opening through the stairway at one end (for what purpose no one could imagine). This opening was 4½ feet above the floor. Another wall (shown in Fig. 1) had five-foot-high bookcases built into each corner, flanked by two small, high windows. These provided little daylight, were difficult to drape, and complicated the solution of the lighting problem. Hence they were plastered over, as was the framed opening on the opposite wall. (If the picture in Fig. 4 seems high, it is because it is covering this replastered section.)

The lighting problem included the usual ones of adequately providing for reading in four or five places in the room, plus a comfortable background of light for viewing television. Formerly there had been only two possible reading spots, and these most inadequate. In the average living room one would expect to provide local lighting with portable lamps properly selected and placed. However, this room was unusual in that the furniture arrangement made it very difficult to solve the local lighting problems by the use of portable lamps. There were no end tables in the room and only one place where a lamp table would have been suitable, decoratively. The davenport was placed snugly between the bookcases, leaving no room for either table or floor lamps. There were two upholstered chairs in the room. The more comfortable of these was placed near one end of the picture window for good daylighting. Although a floor lamp had formerly been used by this chair it did not look well and there was not room enough to place it in a visually comfortable position at the back corner of the chair. These difficulties suggested some form of solution that would depend upon structural elements already in the room or that could be appropriately added. Reflector lamps suggested themselves because of their compactness and ability to deliver recommended reading levels of light at distances of several feet. However, for comfortable brightness ratios between visual task and surroundings a generous amount of general lighting was also needed. Therefore, the function of a ceiling unit was most important here. Similarly it was important that the ceiling and walls have reflectances of not less than 70 per cent and 50 per cent respectively. The fixture selected was a semi-indirect one with a twenty-inch shallow ceramic glass bowl, designed for use with five 60-watt lamps. Its eleven-inch suspension from the ceiling assured a good distribution of light and a comfortable brightness relationship between fixture and ceiling (Fixture 120 to 350 ft-L; ceiling above it, 380 ft-L max). It provided, with the help of a white ceiling and light grey (50% RF) walls an average of nearly ten footcandles on a 30″ plane.

The principal problem in the room was the davenport wall. The position of the bookcases suggested their being continued up to the ceiling and across, to form the top of a cornice to shield fluorescent

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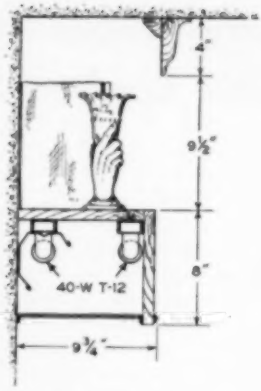
Figure 1 (inset).



Figures 2 (left) and 3 (above).

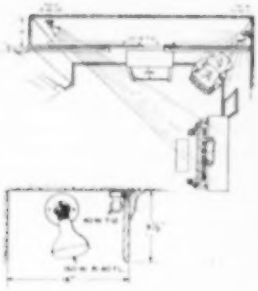
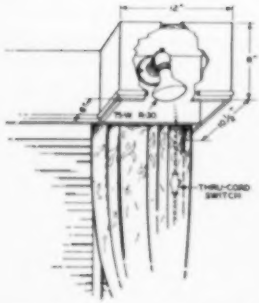


Figure 4.

Figure 5



Figures 6 (left) and 7 (above).

Description of Photographs

Lack of light for reading at the davenport (Fig. 1) greatly limited usable seating space. The position of windows and cabinets made a lighting solution by conventional methods very difficult. The ceiling luminaire was seldom used because its light was unpleasant.

As seen in Fig. 2, the room's appearance and usefulness were both greatly improved by eliminating the awkward windows and by installing the bookcases and soffit lighting over the davenport. The prized ancestral portrait, scarcely visible before now can be fully appreciated. The ceiling unit has an important place in improving the quality and flexibility of lighting.

Detail of the soffit lighting is shown in Fig. 3. An asymmetric reflector on the inner row of lamps increased the value of light for reading. The other row, separately switched, was used for lighting the portrait and for conversation lighting.

Figs. 4 and 5 show the ceiling cornice, which conceals two 40-watt fluorescent lamps, 16 inches from the wall to give even distribution of light. Also concealed are two 150-watt reflector lamps; one, a spotlight lamp for lighting the music sheet; the other, a floodlight lamp to provide light for reading at the small upholstered chair.

Lighting at the window is shown in Figs. 6 and 7. In the corner "boxes" at valance ends are 75-watt R-30 flood lamps directed at book positions in the two chairs directly beneath. The luminaire, which is shown in Fig. 2, is always lighted for reading to reduce contrast between book brightness and surroundings.

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lamps. Two rows of 40-watt lamps were used, two lamps per row, separately switched. An asymmetric reflector was placed behind the inside row to increase the amount of light at reading levels (see Fig. 3). An eight-inch-deep board fastened to the bottom of the shelf shielded the lamps from room positions. A simple moulding strip fastened to the wall and another strip on the back of the shielding board was all that was needed to hold in place two four-foot sections of lightly etched clear plastic to give this soffit-like unit a more finished effect. Standard warm lamps were used in the reflector while de luxe warm were put in the row which lighted the wall and the greatly-prized ancestral portrait.

It was desirable to balance the davenport cornice with a similar effect at the opposite end of the room. A sixteen-inch setback from the hall door to the main part of the wall offered an opportunity for a 9½-inch-deep cornice in line with the doorway. Two 40-watt de luxe warm fluorescent lamps were mounted end-to-end on the ceiling close to the back of this cornice. Because of the sixteen-inch distance from cornice to wall there was not the usual "hot spot" which is apt to be disturbing when viewing a television set placed directly beneath a cornice or valance. The brightness of the wall just above the set was only 29 footlamberts. Maximum brightness just below the cornice was 45 ft-L, while the cornice face measured 5 ft-L, with the ceiling fixture lighted.

The 9½-inch depth of the cornice and its distance out from the wall (16 inches) provided space to conceal two 150-watt reflector lamps, one to light the small upholstered chair in the corner and one to light the piano (see Figs. 4 and 5). For the latter, a spotlight lamp provided an average of 30 footcandles on the music sheet. It also lighted the wall above the piano for a comfortable three-to-one brightness contrast between it and the music. A floodlight lamp in a swivel socket was fastened close to the ceiling above the small upholstered chair. It was shielded from other room positions by the cornice board, and provided 28 footcandles at book position.

Thus far in the planning the davenport, one chair, and the piano had been lighted to 20 footcandles or better. There remained two more chairs, located at each end of an eight-foot picture window beneath which was a six-foot sill-high radiator. Because these chairs were placed very close to the wall and in line with the ends of the window it was possible to design a special valance with deeper "boxes" at the ends, and to mount in these, 75-watt R-30 reflector flood lamps. These boxes were made deep enough (10") to shield the lamps from all seating locations in the room, and were constructed so as to protect the draperies from the heat of the lamps. They provided an average of 20 footcandles at normal reading positions. From one of these positions the reader would face the lighted wall behind the davenport; from the other, the lighted wall behind the television set. These lighted walls plus the substantial general lighting provided by the fixture, made it possible to achieve comfortable brightness relationships when using the floodlight lamps for reading. Book brightnesses averaged 16-18 footlamberts, floor 1.5 ft-L, and lower part of walls (in the visual field when reading) 3 to 5 ft-L, with the light very evenly distributed.

There are several possible combinations of lighting, so that there may be variation according to

occasion and need. The fluorescent cornices at either end of the room are effective as conversational lighting, with the fixture added when a higher-key lighting is wanted—or when card tables are arranged anywhere in the room. The fixture is a necessary addition to the spotlighting whenever piano practicing or other close visual work is done. It also makes television viewing more comfortable when seated at the recommended distance of 9 to 11 feet from the 12½-inch tube set. At this distance the fixture itself is not in the visual field of the viewer but its light is helpful in reducing contrast between screen brightness and surroundings.

Putting it all together, the thing that most impressed the Smiths (that really *was* their name) was that without rearranging, adding to or subtracting from the furniture, the room seemed much larger than before. It was just that one could *see* all of the room and not just the small circles of light around the lamps. Lighting the two end walls had the effect of pushing them away, to give more room in which to live. It seemed impossible, too, that the same furniture could look so much better, but it did. Another satisfaction never before enjoyed in this room was that of being able to sit down *anywhere* in the room to read with comfort. It was more fun to entertain too, because the room looked so much more attractive and made everyone feel more comfortable. Guests never failed to compliment them on the lighting — always a satisfaction to a host! All in all, they wondered how they, who pride themselves on having a comfortable, livable home, and who have purchased most of the major electrical labor-saving appliances, could have overlooked good lighting for so many years. They wondered how they could have stumbled along (almost *literally*) with such old-fashioned and completely inadequate lighting equipment, without realizing any of its inadequacies.

WALL CABINET for holding glassware and china is lighted by recessed luminaires with two 40-watt 4500K fluorescent lamps. The mirrored back of the cabinet is of light blue glass. Shelves are glass. Walls are salmon pink. The lighting is controlled by a wall switch. *Photo courtesy of Detroit Edison Company, Detroit, Michigan.*

Temperature Problems in Incandescent Lamp Luminaires

By REUBEN E. LAGERSTROM

WHEN experience in the field had indicated that certain types of surface-mounted luminaires were causing deterioration of the building wiring, Underwriters Laboratories called in for re-examination all of the surface-mounted, glass-enclosed luminaires using filament type lamps in a horizontal position. In some instances this type of equipment is mounted on ceilings of combustible materials, and there are cases where such materials were scorched from the temperatures encountered in practice. This recall of approvals has caused some confusion in the trade. It may be well, therefore, to review temperature problems in the several different types of incandescent equipment.

The incandescent lamp produces light as a by-product of heat. Therefore, this lamp is the source of heat with which we are basically concerned. Many people have been under the impression that short lamp life is the first sign of trouble in case of excessive temperatures. This can be true in some applications, but is usually not the case in luminaires for general lighting. Since luminaires of this type usually use lamps of 40 watts and up, we will assume that the lamps are gas-filled lamps. The first noticeable effect of high temperature on the lamps is likely to be a blistering of the bulb. At the softening temperature, the gas pressure inside the bulb usually will exceed atmospheric pressure and the bulb will show an outward blister. For ordinary glass of the type used in most lamp bulbs, the maximum safe temperature is considered to be about 375°C.

In order for high ambient temperatures to have a noticeable effect on lamp life, it is necessary that the glass approach a softening temperature. Glass has a tendency to give off moisture (devitrify) as its temperature approaches the softening point, and moisture has a very adverse effect on the life of the lamp filament. In an effort to remove all moisture, leading lamp manufacturers exhaust lamps at a glass temperature close to the softening temperature. So close to softening are the lamps at this stage, that manufacturers do not draw a complete vacuum before filling the bulb with gas, but rather "wash out" the air with gas so as not to have too great a differential in pressures within and without the bulbs. Should you ever see a lamp with a blistered bulb, look also for the excessive blackening and long black strings like spider threads inside the bulb which are sure signs of moisture.

Next in importance, but probably worse from the standpoint of nuisance, is a tendency for lamp bases to become loose from operating for long periods in excessively high temperatures. Where lamps are operated in a vertical position base up, this may occur before bulb wall temperatures become critical. The maximum safe operating temperature for ordinary basing cement used on the lower wattages is 175°C.[1] This is frequently exceeded in luminaires equipped with high-wattage lamps operating in a vertical position base up. Therefore, most general service lamps of 300 watts and up are either based with a high temperature cement developed in recent years or equipped with bases that are mechanically locked to the bulb.

The solder contacts of the lamp bases are also a possible source of trouble from high temperatures. Here, the design of the socket is of greater importance than the ambient temperatures in the fixture. A loose contact at the center frequently is found in sockets of poor design. This results in a high-resistance contact which can build up temperatures over a long period to the point where the solder will melt and run. It is possible for the molten solder to short out the socket and cause a great deal of trouble. Ares can form across the leads which may travel back into the building wiring for several inches.

Frequently, the question is asked, "Won't the higher ambient temperatures raise the filament temperature and thus shorten lamp life?" In theory this may be true, but in practice, there is so wide a difference between filament temperatures and bulb wall temperatures, that the bulb blisters and fails long before the high temperature can have appreciable effect on filament burn-out time. Also, the higher ambients will increase the gas pressure

Author: Member, I.E.S., Oakland, Calif.

within the bulb which in turn will tend to slow the evaporation rate of the filament. In general, higher gas pressures result in increased lamp life, or, in higher efficiencies for a comparable life.

In general, in the case of gas-filled lamps, the hottest part of the bulb is that which is directly over the filament. This is caused by the normal convection currents inside the bulb, which form a column of hot gas rising from the filaments. For a 200-watt lamp operating vertically in an ambient of 25°C, the temperature of the socket shell is of the order of 95°C, that of the basing cement about 100°C, the points on the maximum diameter of the bulb about 88°C, the bottom of the bulb about 90°C, while the glass of the neck of the bulb directly over the filament will be about 153°C. If we operate the same lamp in a horizontal position, the point at the maximum diameter of the bulb directly over the filament will be about 225°C.[2]

Operating Position

In any general-service lamp, the distance from the filament to the base is much greater than the distance from the filament to the maximum diameter of the bulb. Therefore, our problem with the temperatures of lighting fixtures is much greater where the lamps operate in a horizontal position than where they operate in a vertical position. Since all general-service lamps maintain their light output better when operated in a vertical position base up, the reasons for operating them in a horizontal position are all concerned with aesthetic values of design — an eternal fight to keep vertical dimensions small. This factor also frequently dictates the mounting of the fixture directly onto the ceiling, which means that the hot filament, about 2500°C, is sometimes only 2 inches to 3 inches below a ceiling which may be of combustible material. Further, the hot spot on the bulb, as high as 225°C, may be but a fraction of an inch from inflammable material. This calls for careful design to avoid trouble.

Some would say that the answer is to ventilate the fixture and let the heat out. That this is a fallacy in the usual case was proved many years ago by Brown and Dows in an I.E.S. paper.[3] They showed that ventilated fixtures were inclined to run hotter than non-ventilated fixtures because the chimney effect caused by the ventilation concentrated the heat at the very points where high temperatures were not tolerable. This also causes fixtures to get dirtier than without ventilation since the more violent convection currents carry more dirt and dust.

Some of the early editions of the National Electric Code specified that certain types of fixtures must be ventilated. Later, this provision was dropped but other construction details were included in an effort to keep temperatures within safe limits.

Now, the testing bodies no longer specify how a manufacturer shall build his fixtures beyond specifying certain minimums for structural strength, but rather have elected to specify certain temperatures which may not be exceeded. Thus, the temperature of the building wire may not exceed 60°C, and the temperature of the metal parts touching the ceiling may not exceed 90°C. No part of the ceiling over the surface mounted fixtures may exceed 90°C. So long as the manufacturer's product meets these requirements, the testing agencies will not refuse to approve it because of high temperatures. Type AF wire must be used in wiring the fixture where lamps are operated in a horizontal position, and in all incandescent fixtures with mogul sockets.

One way of reducing the temperature of building wire without adding bulk to the fixture is to provide a dead air space between the outlet box and the lamps. This is accomplished by capping the outlet box in such a way that the asbestos insulated wire must pass through a small bushed hole to make junction with the building wire. This will reduce the heat transferred by convection. A pad of asbestos or other insulating material will reduce the amount of heat conducted by the metal parts of the fixture. This still leaves us with a substantial amount of heat in the form of infra-red radiation. Infra-red radiation will pass through a dead air space, or even a vacuum, but it is effectively reflected by aluminum. Thus the combination of a reflector, an insulating pad, and a dead air space can be used to keep temperatures at the critical points within specified limits.

The capping of the outlet box gives several advantages. The building wires are kept in place in the box, the fixture is automatically centered under the box, and the stud mounting of the fixture simplifies installation. It also permits a much shallower mounting pan at the ceiling, which is the basic reason for having this type of fixture. Where outlet boxes are not capped, it must be assumed that the temperatures in the outlet box will be about the same at those in the space between the pan and the ceiling. It cannot be assumed that building wires will stay up in the outlet box that is not capped. Therefore, units which do not provide for capping the outlet box are apt to be quite bulky in order to stay within temperature limitations.

Recessed equipment for incandescent lamps is

considerably more complex than surface mounted fixtures. Since it is built-in, it is even more important that this type of equipment be made in such a way as to give trouble-free operation. To make sure that high temperatures do not cause trouble, the testing agencies make their measurements with the fixture operating in a rectangular box made of half-inch lumber, reasonably air-tight, but not sealed, and of such dimensions that the inside surfaces of the box are half-inch from the nearest point on the recessed portion of the fixture enclosure. With this arrangement, and with a lamp of highest permissible wattage operating in the fixture, the following temperatures may not be exceeded:

1—90° C on any point on the inside surface of the wooden test box including points of support and points in contact with the frame.

2—150° C at any point on the outside of the fixture enclosure not in contact with the test box.

3—200° C on the lampholder screw shell and center contact and on other current carrying parts.

Recessed Equipment

In recessed equipment the lamp bulb may be operating in a vertical or horizontal position or in some position between these two positions. Here again, the temperature problems are simplified when the lamp operates in the vertical position base up. The construction of the lamp bulb then gives some protection against the rapid transfer of heat to the fixture, and permits this heat to be spread over larger areas. In this case, the socket temperatures become a point of principal concern. Well designed sockets are essential to maintain good electrical contacts under conditions of high temperature.

Where lamps are operated in the horizontal position in recessed equipment, the temperature of the container becomes a primary consideration because of the close proximity of the metal parts of the container to the hottest part of the lamp bulb. Reflectors and pads of asbestos or other insulating material are important factors in the reduction of temperature at the hottest points. Here again, the testing agencies do not specify how the manufacturer shall build the equipment, but approve or reject the equipment on the basis of temperature measurements as shown above.

From a commercial standpoint, recessed lighting equipment is much more salable when it is made in such a way that it does not permit light to leak onto the ceiling from between the seams in the frame or the housing. It is also desirable to have these units made as tight as possible so that a minimum of dust is admitted via convection currents. Therefore, ventilation is not desirable. The equipment may be mounted in material that has very low heat conductivity, so it is not good practice to depend on very much of the heat to be carried away by conduction. The bulk of the heat transfer from this type of unit must then, be by radiation.

But the maximum permissible temperature of the outer container (150° C) does not indicate a high rate of heat transfer by radiation. Thus, the problem of staying within the temperature limits and keeping the housing small is a tough one. It is so tough that some manufacturers have made their recessed equipment with vents in the outer container. It is doubtful that these contribute very much to lowering the maximum temperature, and the attendant problems of dust in the interior of the unit would seem to discourage their use.

In actual installation, any heat-insulating materials which are less than a half-inch from the outer container will tend to raise the temperature of the enclosure. Since most heat insulating materials liable to be encountered in this type of construction are not fire-proof, this is a factor which cannot be ignored.

Wiring practice for recessed lighting equipment seems to vary with the interpretations of the code. Each inspector seems to have a definite idea of what the code means, but there is no unanimity of opinion. One group requires that the junction box serving the fixture be as close to the opening as possible; one requires that a minimum of four feet of flex be used between the junction box and the fixture; one says that it should be a maximum of four feet; one says that the cover of the outlet box must be exposed on the ceiling. The advent of junction boxes as a part of the fixture was supposed to end all these disputes. However, there are additional factors introduced here as to the number of circuits that are permissible in such boxes.

Temperature of the building wire is just one of the factors involved here, although it is a very important one. Since the maximum safe temperature for code grade wire is 60° C, that is the maximum permissible temperature for wire and insulation in any junction box that is served by building wire. The accessibility to this junction with the building wire is the factor that introduces all the restrictions of installation practice.

Suspended types of incandescent fixtures give least temperature problems. Here the lamps usually are located at a distance of many inches from the outlet box. Fixtures for incandescent lamps equipped with mogul bases are required to be wired with Type AF wire. Only in special cases does the

temperature in this type of fixture run so high as to cause trouble with this wiring.

The 1000-watt T-24 bulb, general service lamp introduced some special problems when it was new. The bi-post type of construction used here is one that permits the hot filament to be very close to the connecting wires at the socket. The sturdy channels within the bulb are good heat conductors, and the first problem came in the design of a socket that would maintain good electric contact, and would not freeze the lamp to the socket. At the high temperatures involved, it was found necessary to use special alloys so that they would not lose their spring tension. Some of these alloys had a property of amalgamating to the metal of the lamp contact so that it was virtually impossible to get a lamp out of the socket when it was burned out.

The solution to these problems left a very serious one in that the stranded wire used for fixture wiring corroded or crystalized rapidly with the high temperature, and the electrical contact was broken. Nickel plating the wire did not seem to be the answer until one manufacturer tried a stranded wire in which each strand was individually nickel plated. While heavy plating was helpful, only strands of solid nickel proved adequate over a long period. This is the only known satisfactory method of wiring such sockets.

So long as we use light sources which produce light as a by-product of heat, we are going to have to consider the factors of high temperature in the design of fixtures for those lamps as factors of primary importance. However, the laws of heat transfer are well known and generally understood by engineers. The astute engineer will find ways to build fixtures to keep temperatures within safe limits.

References

1. Lamp Bulletin, LD-1, General Electric Co., May 1946, page 22.
2. *Ibid.*, page 21.
3. Brown and Dows, *Transactions of I.E.S.*, No. 7, p. 284, 1921.

DATA SHEETS—A NEW LOOK

In this issue a new era has arrived in a streamlined appearance of Lighting Data Sheets. Since 1928 the Data Sheets have played a stellar role in bringing to designers and the public honest-to-goodness installation reports illustrating our Recommended Practices. Hundreds of architects and engineers have become conscious of what lighting can really do through the regular visits of Data Sheets into their offices. Hundreds of lighting engineers have been able to show customers illustrations of types of lighting which they propose. Best of all, these illustrations are of "certified" installations because they have been carefully screened, measured and checked for illumination values, brightnesses, and reflectances. The range of subject coverage is remarkable; in a recent survey of industrial material published by the Society it was found that the Data Sheets covered many processes and specific locations which are not covered anywhere else in the literature. This is especially helpful to designers who have problems they have never before encountered.

However, there is a tendency for all good functions or services to become commonplace with a gradual decline of interest. Change of pace is the essence of attraction and interest. Architectural magazines have conducted surveys of readership interest. The average busy reader scans a magazine looking at the pictures, thus obtaining a "gist" of the contents. In view of this the answer becomes: *maximum pictorial presentation* with a *minimum of words*. This idea sounds modern, progressive and functional. Actually it is no newer than the old proverb: "A picture is worth a thousand words."

In view of these surveys, the architectural magazines are specializing in large dramatic pictures and accompanying sketches to give the ideas at a glance. Surely the Data Sheets are a "natural" for this "new" approach — a large photo, a sketch of the lighting concept, a footcandle table, brightnesses, reflectances and colors, and a *few* words to describe the lamp types and equipment catalog numbers. Here you have it — a complete design and performance report on a single sheet ready for the busy architect and designer to appreciate and use.

All this has now been put up in an attractive streamlined, professionally designed package that all our people can be proud to present to their public. Let us use to its full capacity this old tool in its new form for the maximum benefits to the designer and user of lighting.

C. L. Crouch, *Technical Director*
Illuminating Engineering Society.

INSTALLATION AT DON BOSCO HIGH SCHOOL, 1331 WEST BECHER STREET, MILWAUKEE, WISCONSIN

Lighting a Gymnasium

LIGHTING OBJECTIVE: To provide lighting suitable for the diversified activities in a high school auditorium-gymnasium.

GENERAL INFORMATION: The gymnasium floor measures 94 x 83 feet. Ceiling height ranges in an arc from 11 feet at the side walls to 29 feet in the center. The area is used for a wide range of activities, for example: basketball conference games, practice games, general gymnasium activities, high school theatricals and dances.

INSTALLATION: Eight continuous rows of especially-designed Daybrite louvered bottom troffer units each containing three 96-inch 3500K T-8 slimline lamps operating at 300 ma are combined with indirect coves (Daybrite #1270), built into the ceiling, one beside each troffer, with similar lamps operating at 120 ma. The system can be switched to provide 18, 35 or 50 footcandles. The coves are covered with colored filters to provide a special lighting effect for dances and parties.

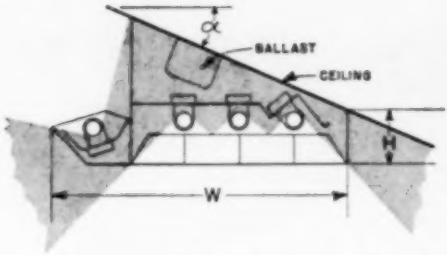
(over)

A.I.A. File No. 31

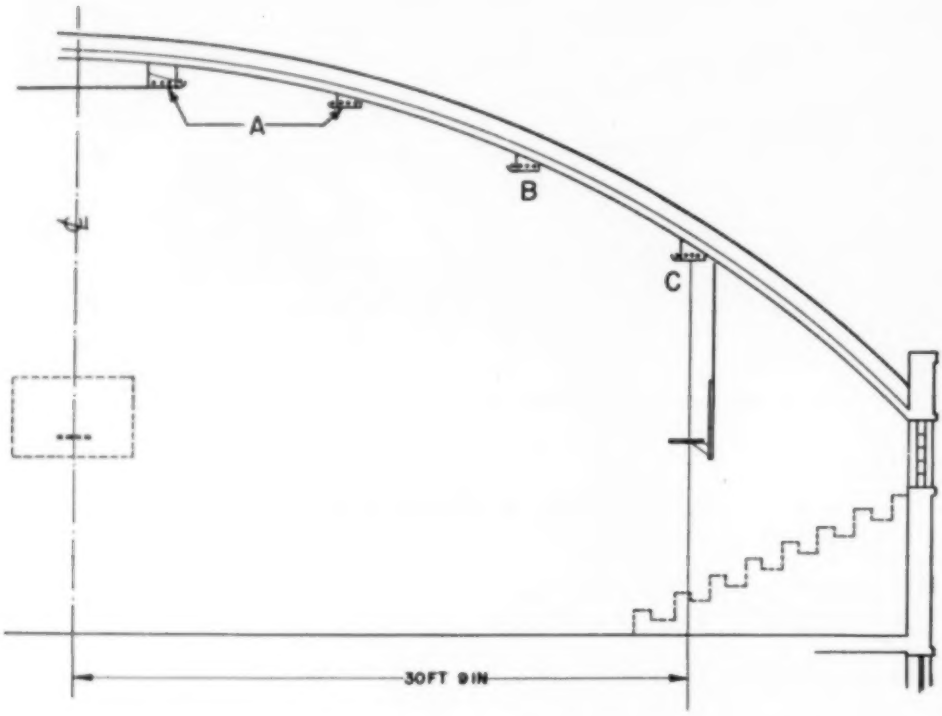
Lighting a Gymnasium (continued)

Brightnesses are as follows:

sidewalls	15 to 20 footlamberts
end walls	20 footlamberts
luminaire louvers	300 to 400 footlamberts
ceiling (with colored shields over coves)	3 footlamberts



$\alpha_A = 15°$	$\alpha_B = 24°$	$\alpha_C = 32°$
$H_A = 4\frac{1}{4}"$	$H_B = 3\frac{3}{4}"$	$H_C = 2\frac{3}{4}"$
$W_A = 18\frac{3}{4}"$	$W_B = 18\frac{3}{4}"$	$W_C = 18\frac{3}{4}"$



Installed by Staff Electric Co., Milwaukee; architects: Brust and Brust, Milwaukee.

Lighting data submitted by Thomas B. Dustin, Milwaukee, Wisconsin as an illustration of good lighting practice and to aid in the design of similar installations.

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Living Room

Before: In typical living areas, 175-300 sq. ft., floor and table lamps even of inherent good lighting design fail in providing comfortable reading conditions without general lighting. This room is equipped with six, each with diffusing bowl, totalling 1100 watts. As davenport and chair are placed, they cannot be appropriately lighted. Furniture rearrangement was thus basic in the lighting plan, and, and proved much better in the living plan.

After: New in the Certified portable family is this lamp, 300-watt table type (40 ft-c), under 25". A pair serve reading hours well at this end of the room. Three of the original portable lamps were used, the final five totalling 1200 watts. Carefully engineered units packaged to fit varying window sizes, reduce the cost and design hazard of custom-built units, making window and wall valance lighting practical for average families. (Units available with and without front shielding but with complete fittings for simple hanging faceboard attachment and for plug in or permanent wiring.) Twenty-two feet (8 25-watt lamps) fit the window openings and provide general lighting despite top covering on one valance (due to height). No surface brightness in the room exceeds 120 ft-L.

Ready-Made Answers To Home Visual Needs

By MARY WEBBER

MANY factors of late add zest to the work of those who are devoted to the lighting of homes. The greatest it seems is the recent upswing in better luminaire design, particularly in ceiling and wall units. The improvement is tremendous in tasteful appearance, in price range, and in *designed purpose* for a *specific lighting application*. Promising for the needs of the average family, they are catalogued by several leading manufacturers. Only with widely available ready-made luminaires, can any but the higher income families ever afford even the most basic of lighting's services.

In a recent report of the I.E.S. Residence Lighting Committee,* some fifteen visual activities, common to everyday family living, were described — the location and extent of the area to be lighted, as well as the recommended illumination defined. When conscientious answers to these realistic problems are obtained, the overall lighting is also complete for typical 900 to 1200 sq. ft. homes. In addition to functional answers there is a livable, flexible and pleasant environment. But the luminaire requirements are far greater than have been supplied in the millions of homes built since the war.

Generally, these modest homes had ridiculous fixture allowances from as low as $7.00 to $30.00! A total of seven fixtures was far too common — in fact is still an average for all five-room homes. Whereas in reality a minimum of twenty surface-attached (wall or ceiling in both interior and exterior), and more often twenty-five to thirty are needed. If recessed or custom-built equipments are used for any of the applications, their added cost (in labor and supervision) rob other locations of needed light if budgets must be adhered to. Fixed lighting in every room of the home is as much a functioning element essential to modern living as is its plumbing, heating, daylighting or interior finishing, and it costs much less than any one of those. Rational budgets are in the order of $150.00 to $300.00 for $8000 to $20,000 homes (of approximately 1000 sq. ft.). About ten to fourteen portable luminaires complete the lighting in the same area houses.

General Electric Co., Nela Park, Cleveland, Ohio.

*"The Functional Visual Activities in the Home, ILLUMINATING ENGINEERING, Vol. XLVI, No. 7 (July 1951).

Dining Room

Before →

← After

Before: Designed for low hanging in dinettes, this 50-150w luminaire does nothing to enhance table setting, environment or family spirit.

After: New three-effect, close-to-ceiling types with theatre-like spotlighting are now priced for the most modest homes. The downlight, giving 15 to 75 ft-c depending on the lamp for which the unit is designed, with an additional 10 to 15 ft-c from four or five 40w lamps behind glass shielding make the table usable for games, sewing, sorting, etc. Standard 25w fluorescent bracket hidden behind shelf trim and plugged into buffet outlet, gives many times its cost in delight and usefulness. Packaged 66-inch window valance (carpenter-built shield) is also lighted. Total lighting installation costs less than half that of floor covering.

Bedroom

← Before

After →

Before: The possible light output of 3-socket luminaires as small as 12 inches diameter is hardly worth their normal low price. This one originally cost as much as its more worthy and pleasing replacement. The "popular" bedside lamp gives only an impression of light from white draperies.

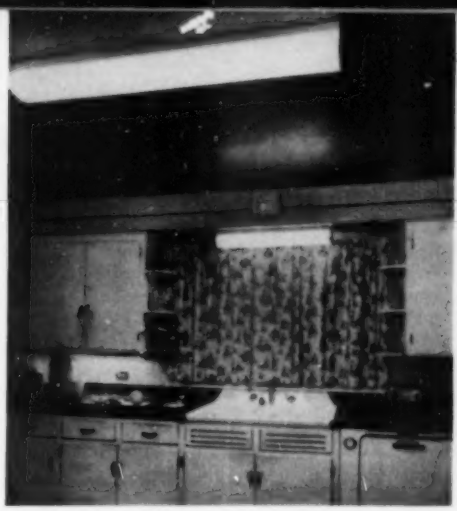
After: New packaged wall lamps, with R-40 lamps, provide 25 ft-c on the book and not in the eyes. Shallow ceramic glass forms, simple design, 4- or 5-sockets, sizes of 15 to 22 inches across characterize the better functioning ceiling units for bedrooms. Maximum brightness here is 950 ft-L at small areas below lamps (five 60w white). In general, a ¾- to 1-inch spacing between lamps and glass instead of the usual ¼-inch would create more even and lower brightness, greater width of glass affording lamp shielding from usual viewing angles. Ceiling gloss was removed by a coat of buttermilk. Maroon walls were not repainted. Bedspreads are white.

One of several packaged styles of fluorescent bed lamps, available for permanent wiring (for most bed heights, horizontal outlet 53 inches above floor) or plug-in wiring, with a 25w minimum size for 20 ft-c. Those with semi-direct distribution like this one give higher levels of illumination per watt (35 ft-c here) mounted 30 inches from mattress to lower edge. Prices are comparable to those of appropriate bedside table lamps.

Kitchen

← Before

After →



Before: The too-small center globe (under 10 inches) and recessed sink light use 100w each, give a false impression of useful light because of their brightness. A light meter registered only 8 ft-c directly under the units and less than 2 ft-c on counters.

After: In better harmony with the cost, appearance and efficiency of the planned electric kitchen are fluorescent luminaires (usually a minimum of four in the average kitchen) located with respect to work centers. Those shown represent improved designs and values; use de luxe warm lamps (instant start in center unit) and provide 25 to 40 ft-c at all work locations. Average brightness, on plastic covers, 1000 ft-L. Lighting equipment and installation cost the owner less than 10 per cent of that for electric kitchen appliances.

Where lighting leadership is alert, many families in homes of this class are today experiencing the utterly new lighting qualities possible with informed use of ready-made luminaires. No single home can of course illustrate all the excellent new designs. The accompanying pictures, however, show a fair cross-section of types in the medium price range. They were taken in a ten-year old home of a newspaper man who feels he and his wife made their home "as new and fresh as today" with light.

Relatively few persons have as yet seen the newest designs. Our experience is that when they do there is an enthusiastic approval, previously lacking, especially when their purpose and effects are demonstrated. Obviously there is need of education, smart display, convincing demonstration. On the charted road of progress is better lighting to which our Society members are dedicated, "it seems to me" they will want to express their leadership by keeping their own homes in step.

Stove Lighting

For stove lighting, a custom-made luminaire was purchased. Metal end plates to hold an open-at-top plastic shield (170 ft-L) were attached to a standard unshielded bracket for better harmony with ceiling and sink units than that supplied by ready-made ones. Equivalent level of 30 to 40 ft-c is provided. Outlet height is 60 inches above floor.

→

For use in the bathroom, glass shields to clip on 1-inch diameter tubular lamps are now packaged. (Clips should be wound with friction tape.) These allow change from 30 to 60w lamps in the brackets attached to the medicine cabinet. Further improvement (40 ft-c on face and top of head) is gained by addition of an appropriate ceiling luminaire located over the front of the wash bowl.

A Basis for Predicting General Room Illumination in the Home

By PRISCILLA PRESBREY
EDITH L. BUCHHOLTZ

Coefficients of utilization for forty types of residential luminaires are presented for use in the standard lumen method of calculating illumination. A table of room indexes adapted to residential purposes is also given.

THE LUMEN METHOD of predicting interior illumination has long been used in designing industrial and commercial lighting installations. Pertinent efficiency and distribution data for luminaires used in such applications are usually available from the manufacturer.

However, in the residential field this method has seldom been applied. The lighting of a residence, in contrast to industrial and commercial lighting, is greatly influenced by the styling and furnishings of the interior, and by the individual preferences of each member of the family. It is not only a problem of selecting lighting equipment that will supply satisfactory levels of illumination, but also one of providing the aesthetic satisfaction and decorative effect desired by the family.

Perhaps this, more than any other one factor, has retarded the use of engineering methods in residential lighting applications. However, the time has passed when appearance and period styling must be sacrificed if acceptable illumination is to be provided. Today there is a wide diversity of residential lighting equipment engineered to combine the art of decorative design with the science of illumination.

With this advancement, and with the increased interest in adequate lighting levels in the home, the need for predicting the probable illumination provided by various types of luminaires in specified interiors becomes more pronounced. It is the purpose of this study to furnish data for applying the lumen method of lighting calculation to the field of residential illumination.

Selection of Luminaires

An effort was made to select a group of general lighting luminaires representative of the wide variety of available designs, and including suitable equipment for each type of room in the home. In most cases, luminaires with good lighting characteristics and acceptable styling were chosen; however, several less desirable luminaires have also been included because of their present widespread use in low-cost or rental housing developments.

Laboratory Tests

For most of the luminaires listed in Table II, candlepower distribution and efficiency were determined in the laboratory, and distribution curves were plotted in terms of the rated light outputs of the sources. The necessary photometric data for the calculation of coefficients of utilization were already available for a few of the fixtures.

Consideration was given to the possibility of using simulated ceilings in testing ceiling-mounted luminaires, as is common practice with commercial equipment having an important upward component. Two factors weighed strongly against this procedure — the impracticability of making photometric tests with ceiling plates of four reflectances, and the difficulty of determining when the ceiling plate should and should not be used. Commercial fixtures are either ceiling-mounted or suspended. Residential equipment ranges from fixtures mounted very close to the ceiling to those hung below eye-level over a dining table, with an unlimited number of intermediate positions. There is no line of demarcation between "ceiling-mounted" and "suspended," and no criterion for distinguishing between them. All of the tests reported in Table II were therefore made on the luminaires alone.

Except in very large rooms, the use of a ceiling board has relatively little effect upon the coefficient of utilization, as can be noted in any tables showing

A paper presented at the National Technical Conference of the Illuminating Engineering Society, August 27-30, 1951, Washington, D. C. Authors: Commercial Engineering Dept. and Residential Lighting Dept., Westinghouse Electric Corp., Lamp Division, Bloomfield, N. J.

the same luminaires tested as ceiling-mounted and suspended. However, it is obvious that under some circumstances there may be an appreciable loss resulting from absorption by the luminaire of light reflected from the ceiling immediately above it. Check measurements were therefore made on a unit representative of this condition. A large (18-inch-square) shallow glass close-to-the-ceiling four-lamp fixture was tested with a 75 per cent ceiling plate of the same size as the glass, and the coefficients of utilization for 75 per cent ceiling reflectance were compared with those obtained on the same fixture tested without a ceiling plate. The ceiling plate lowered the light output of the fixture about 30 per cent, but the change in coefficients of utilization was much less. For "J" through "E" rooms, which probably include the great majority of residential rooms, the coefficients were the same with and without ceiling plate, or not significantly different. The maximum difference occurred at the "A" end of the room index scale, and did not exceed 15 per cent. Since the luminaire was chosen as an example of the extreme condition of absorption, and since with ceilings of lower reflectance the ceiling plate would make less change in the coefficients of utilization, it seems certain that failure to use a ceiling plate could have no significant effect on the accuracy of the final results.

Calculations

Coefficients of utilization were calculated by the conventional Harrison and Anderson method.[1] In view of the current decorator trend toward dark walls and ceilings, it seemed desirable to include coefficients for ceilings and walls of lower reflectances than are commonly given for commercial and industrial equipment. Columns for 30 per cent ceiling and 50 per cent wall, and for 10 per cent ceiling with 50 per cent, 30 per cent, and 10 per cent wall, were therefore added to the usual table. The direct component factors for these reflectance combinations for "very narrow," "concentrating," and "focusing" distributions were obtained by extrapolation of the original Harrison and Anderson data, using the published figures for the common reflectances as a guide.

The direct components of several of the luminaires tested were so concentrating that it hardly seemed appropriate to place them even in the "focusing" classification, which is the highest degree of concentration to which the Harrison and Anderson method has been extended. The difficulty appears to lie in the fact that the other classifications (based on the percentage of the direct component lumens in the 0-40 degrees zone) cover a range of only 5 per cent, whereas everything above 60 per cent is included in the "focusing" classification. Among the "focusing" luminaires tested were those with ratios ranging from 70 per cent to 95 per cent, and one with a relatively high horizontal candlepower which gave a figure of 118 per cent! In these cases that part of the coefficient of utilization contributed by the direct component is undoubtedly too low, and calculation by some system utilizing the interreflection method would give more accurate results.[2] (This is apparent, for example, if the coefficients given for luminaire 29 in Table II are compared with previously published data on similar projector-lamp equipment.[3] Both sets of figures are based on the output of the reflectorized lamp as 100 per cent.) However, since the Harrison and Anderson method is at present the system officially recognized by the Society, the authors have adhered to it throughout this study. Future developments in calculation methods may indicate the advisability of revising some of these figures.

The lumen method is most often associated with a fairly large area and a number of sources symmetrically located, whereas most of the residential luminaires included in this investigation would ordinarily be used singly in a room. However, the original Harrison and Anderson work[4] was based on measurements of single-fixture as well as multiple-fixture installations. In general the smaller the number of luminaires in a room (if symmetrically distributed throughout the area) the higher their utilization efficiency. Thus a method of computation designed to represent an average for all conditions will give results for single fixtures that are on the conservative side.

Another element which may in some cases tend to produce slightly higher utilization than is indicated in Table II is the fact that the Harrison and Anderson system is based on a floor reflectance of 14 per cent,[1] a figure which is rather low for many modern residential interiors. The effectiveness of the floor in adding to the illumination on the working plane varies considerably with the distribution characteristics of the luminaire and with the shape of the room, but where the floor covering and the furniture are both of high reflectance the coefficients of utilization given in Table II may again be expected to be slightly low.

Table I lists room indexes for the sizes of rooms likely to be encountered in residential lighting practice. The usual table for industrial and commercial purposes has been extended to include lower ceilings and a few smaller rooms, and rooms of dimensions not applicable to the home have been omitted.

TABLE I.—Room Indexes.

Room Width (Feet)	Room Length (Feet)	Ceiling Height — Feet For Indirect and Semi-Indirect Luminaires: 7	8	9	10½	12	13½	15	16½	18
		Mounting Height Above Floor — Feet For Direct, Semi-Direct, and General Diffuse Luminaires: 5½	6½	7	8	9	10	11	12	13
6	6	G	H	I	J	J	J	J		
	8	G	H	I	J	J	J	J		
	10	F	G	H	I	J	J	J	J	
	12	F	G	H	I	J	J	J	J	
	14	F	G	H	I	I	J	J	J	J
	16	F	G	H	I	I	J	J	J	J
	18	F	G	H	H	I	J	J	J	J
	20	E	F	G	H	I	J	J	J	J
	24	E	F	G	H	I	J	J	J	J
	30	E	F	G	H	I	I	J	J	J
8	8	F	G	H	I	J	J	J	J	
	10	F	G	H	I	I	J	J	J	
	12	E	F	G	I	I	J	J	J	J
	14	E	F	G	H	I	J	J	J	J
	16	E	F	G	H	I	J	J	J	J
	18	E	F	G	H	I	I	J	J	J
	20	E	F	F	H	H	I	J	J	J
	24	D	E	F	G	H	I	J	J	J
	30	D	E	F	G	H	I	I	J	J
	35	D	E	F	G	G	H	I	I	J
	40	D	E	E	F	G	H	I	I	J
	50	D	E	E	F	G	H	H	I	I
10	10	E	F	G	H	I	J	J	J	J
	12	E	F	G	H	I	I	J	J	J
	14	E	E	F	H	H	I	J	J	J
	16	D	E	F	G	H	I	J	J	J
	18	D	E	F	G	H	I	I	J	J
	20	D	E	F	G	H	I	I	J	J
	24	D	E	F	G	G	H	I	I	J
	30	C	D	E	F	G	H	I	I	J
	35	C	D	E	F	G	H	H	I	I
	40	C	D	E	F	F	G	H	H	I
	50	C	D	E	F	F	G	H	H	I
	60	C	D	E	F	F	G	H	H	I
12	12	D	E	F	G	H	I	I	J	J
	14	D	E	F	G	H	I	I	J	J
	16	D	E	F	G	H	I	I	I	J
	18	D	E	F	G	G	H	I	I	J
	20	C	D	F	F	G	H	I	I	I
	24	C	D	E	F	G	H	H	I	I
	30	C	D	E	F	F	G	H	H	I
	35	C	D	E	F	F	G	H	H	I
	40	C	C	D	E	F	G	G	H	I
	50	B	C	D	E	F	F	G	H	H
	60	B	C	D	E	F	F	G	G	H
14	14	D	E	F	F	G	H	I	I	J
	16	C	E	E	F	G	H	H	I	I
	18	C	D	E	F	G	H	H	I	I
	20	C	D	E	F	G	H	H	I	I
	24	C	D	E	F	F	G	H	H	I
	30	B	C	D	E	F	G	H	H	I
	35	B	C	D	E	F	F	G	H	H
	40	B	C	D	E	F	F	G	H	H
	50	B	C	D	E	E	F	F	G	H
	60	B	C	D	E	E	F	F	G	G

Room Width (Feet)	Room Length (Feet)	Ceiling Height — Feet For Indirect and Semi-Indirect Luminaires: 7	8	9	10½	12	13½	15	16½	18
		Mounting Height Above Floor — Feet For Direct, Semi-Direct, and General Diffuse Luminaires: 5½	6½	7	8	9	10	11	12	13
16	16	C	D	E	F	G	G	H	I	I
	18	C	D	E	F	G	G	H	H	I
	20	C	D	E	F	F	G	H	H	I
	24	B	C	D	E	F	G	G	H	I
	30	B	C	D	E	F	F	G	G	H
	35	B	C	D	E	F	F	G	G	H
	40	B	C	D	E	E	F	F	G	H
	50	A	B	C	D	E	F	F	G	G
	60	A	B	C	D	E	E	F	F	G
18	18	C	D	E	E	F	G	H	H	I
	20	B	C	D	E	F	G	G	H	H
	24	B	C	D	E	F	F	G	H	H
	30	B	C	D	E	F	F	G	G	H
	35	B	B	C	D	E	F	F	G	H
	40	A	B	C	D	E	F	F	G	G
	50	A	B	C	D	E	E	F	F	G
	60	A	B	C	D	E	E	F	F	G
20	20	B	C	D	E	F	F	G	H	H
	24	B	C	D	E	F	F	G	G	H
	30	A	B	C	D	E	F	F	G	G
	35	A	B	C	D	E	F	F	G	G
	40	A	B	C	D	E	E	F	F	F
	50	A	B	C	D	E	E	E	F	F
	60	A	A	B	C	D	E	E	F	F
24	24	A	B	C	D	E	F	F	G	G
	30	A	B	C	D	E	E	F	F	G
	35	A	B	C	D	E	E	F	F	G
	40	A	A	B	C	D	E	F	F	F
	50	A	A	B	C	D	E	E	F	F
	60	A	A	B	C	D	D	E	E	F
30	30	A	A	B	C	D	E	E	F	F
	35	A	A	B	C	D	E	E	F	F
	40	A	A	B	C	D	D	E	E	F
	50	A	A	B	C	C	D	D	E	F
	60	A	A	B	C	C	D	D	E	E
35	35	A	A	B	C	C	D	E	E	F
	40	A	A	A	B	C	D	D	E	E
	50	A	A	A	B	C	C	D	E	E
	60	A	A	A	B	C	C	D	D	E
40	40	A	A	A	B	C	C	D	E	E
	50	A	A	A	B	B	C	C	D	E
	60	A	A	A	B	B	C	C	D	D
50	50	A	A	A	A	B	B	C	D	D
	60	A	A	A	A	B	B	C	C	D
60	60	A	A	A	A	A	B	B	C	C

Results

Table II gives coefficients of utilization for forty types of luminaires, together with the candlepower distribution curves and efficiencies on which the calculations were based. In plotting the curves the maximum candlepower for each luminaire has been taken as 100 per cent. The curves shown for fluorescent fixtures are those measured normal to the lamp axis. Efficiencies are given as percentages of bare lamp lumens emitted by the luminaire in the upper and lower hemispheres. Efficiencies of luminaires employing silvered-bowl lamps are expressed in terms of the output of the unprocessed lamp.

It should be emphasized that these curves and data do not represent specific luminaires. In several instances where the candlepower distributions were very similar the curves for two or more fixtures have been combined into one. In two or three cases where experience indicated that the efficiency

TABLE II.—Coefficients of Utilization.

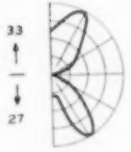
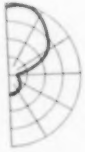
Luminaire	Distribution and Efficiency	Light Sources	Reflectances											
			Ceiling	75%			50%			30%			10%	
			Walls	50%	30%	10%	50%	30%	10%	50%	30%	10%	50%	30%	10%
			Room Index	Coefficients of Utilization										
1 Crystal, Opaque Shades	 33 / 27	5 A-19, Base Down	J	.20	.17	.16	.18	.16	.15	.16	.14	.13	.14	.13	.12
			I	.24	.22	.21	.22	.20	.19	.20	.18	.17	.17	.16	.15
			H	.27	.25	.23	.24	.22	.21	.21	.20	.19	.18	.18	.17
			G	.30	.27	.26	.27	.25	.23	.23	.22	.21	.20	.19	.19
			F	.32	.29	.27	.28	.26	.25	.24	.23	.22	.21	.20	.20
			E	.34	.32	.30	.31	.29	.27	.26	.25	.24	.23	.22	.21
			D	.37	.35	.33	.33	.31	.29	.28	.27	.26	.24	.23	.23
			C	.39	.36	.34	.34	.32	.31	.29	.28	.27	.25	.24	.23
			B	.41	.39	.37	.35	.34	.33	.30	.29	.28	.25	.25	.24
			A	.42	.40	.39	.37	.35	.34	.31	.30	.29	.26	.25	.25
2 Etched Glass Chimneys	53 / 32	5 A-19, Base Down	J	.19	.14	.11	.16	.12	.09	.13	.09	.08	.10	.08	.06
			I	.23	.18	.15	.20	.16	.13	.17	.13	.11	.13	.10	.09
			H	.27	.22	.19	.23	.19	.16	.19	.16	.13	.15	.12	.10
			G	.31	.26	.22	.26	.22	.19	.21	.18	.15	.17	.14	.12
			F	.34	.29	.25	.29	.24	.21	.23	.20	.17	.18	.15	.14
			E	.39	.34	.29	.33	.28	.25	.26	.23	.20	.20	.18	.16
			D	.42	.37	.33	.36	.32	.28	.29	.26	.23	.23	.21	.19
			C	.45	.40	.36	.38	.34	.30	.31	.28	.25	.24	.22	.20
			B	.50	.45	.41	.42	.38	.35	.34	.31	.29	.26	.25	.23
			A	.52	.48	.44	.44	.39	.37	.35	.33	.31	.27	.26	.24
3 Opal or Opalescent Glass Bowls	 61 / 19	5 A-19, Base Down	J	.19	.15	.13	.15	.13	.11	.12	.09	.08	.09	.08	.06
			I	.23	.19	.17	.19	.16	.14	.15	.13	.11	.11	.09	.08
			H	.26	.23	.20	.22	.19	.17	.17	.15	.13	.12	.11	.10
			G	.30	.26	.23	.25	.21	.19	.1°	.17	.15	.13	.12	.11
			F	.32	.29	.25	.27	.23	.21	.2	.18	.16	.14	.13	.12
			E	.36	.32	.29	.30	.26	.24	.22	.20	.19	.16	.14	.13
			D	.39	.36	.33	.32	.29	.27	.25	.22	.21	.17	.16	.15
			C	.42	.38	.35	.34	.31	.29	.26	.24	.22	.18	.17	.16
			B	.46	.42	.40	.76	.34	.32	.28	.26	.24	.19	.18	.17
			A	.48	.44	.42	.39	.36	.34	.29	.27	.26	.20	.19	.18
4 Opal Glass Diffusing Bowl, Opaque Shade	55 / 20	1 G-30 Three-Light, Base Down	J	.21	.18	.16	.18	.16	.14	.15	.13	.12	.12	.11	.10
			I	.25	.22	.21	.22	.19	.18	.18	.16	.15	.14	.13	.12
			H	.29	.26	.24	.24	.22	.20	.20	.19	.17	.15	.15	.14
			G	.32	.29	.26	.27	.24	.23	.21	.20	.19	.17	.16	.15
			F	.34	.31	.28	.29	.26	.25	.23	.21	.20	.18	.17	.16
			E	.37	.35	.32	.31	.29	.27	.25	.23	.22	.19	.19	.18
			D	.41	.38	.36	.34	.32	.30	.27	.25	.25	.20	.20	.19
			C	.43	.40	.37	.35	.33	.31	.28	.26	.26	.21	.20	.19
			B	.46	.43	.41	.37	.36	.34	.30	.28	.27	.22	.21	.20
			A	.47	.45	.43	.39	.37	.36	.31	.29	.28	.23	.22	.21

TABLE II.—Coefficients of Utilization.

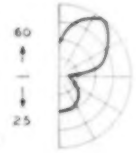
Luminaire	Distribution and Efficiency	Light Sources	Reflectances											
			Ceiling	75%			50%			30%			10%	
			Walls	50%	30%	10%	50%	30%	10%	50%	30%	10%	50%	30%	10%
			Room Index	Coefficients of Utilization											
5 Etched Glass, Ceramic Design	 60 25	5 A-19, Horizontal	J	.22	.18	.16	.19	.16	.13	.16	.13	.11	.12	.11	.10
			I	.27	.23	.21	.24	.20	.18	.19	.17	.15	.15	.14	.12
			H	.31	.27	.24	.26	.23	.21	.22	.19	.17	.17	.16	.15
			G	.35	.31	.28	.30	.26	.24	.23	.21	.20	.18	.17	.16
			F	.37	.34	.30	.32	.28	.26	.25	.23	.21	.19	.18	.17
			E	.41	.38	.35	.35	.31	.29	.28	.25	.24	.21	.20	.19
			D	.45	.41	.38	.38	.35	.32	.30	.28	.27	.23	.22	.21
			C	.48	.44	.41	.39	.36	.34	.31	.29	.28	.24	.23	.22
			B	.52	.48	.45	.42	.40	.38	.34	.31	.30	.25	.24	.23
			A	.53	.50	.48	.45	.42	.40	.35	.33	.31	.26	.25	.24
6 Etched Glass, Ceramic Design, Center Lens	32 33	4 40-W A-19, Horizontal, and 1 100-W A-21, Base Up	J	.23	.20	.19	.21	.19	.17	.20	.18	.16	.17	.16	.15
			I	.27	.25	.24	.25	.23	.22	.23	.21	.20	.21	.20	.19
			H	.30	.28	.27	.28	.26	.25	.25	.24	.22	.22	.22	.21
			G	.33	.31	.29	.30	.28	.27	.27	.26	.24	.24	.23	.22
			F	.36	.33	.31	.32	.30	.28	.28	.27	.26	.26	.24	.24
			E	.38	.36	.34	.35	.33	.31	.31	.29	.28	.27	.26	.25
			D	.41	.38	.37	.37	.35	.33	.32	.31	.30	.28	.27	.26
			C	.43	.40	.38	.38	.36	.34	.33	.32	.31	.29	.28	.27
			B	.45	.43	.41	.40	.38	.37	.35	.33	.32	.30	.29	.28
			A	.46	.44	.43	.41	.39	.38	.36	.34	.33	.31	.30	.29
7 Etched Glass, Ceramic Design, Center Lens	30 30	4 40-W A-19 and 1 75-W A-19, All Horizontal	J	.19	.16	.15	.17	.15	.14	.15	.14	.12	.14	.13	.12
			I	.23	.20	.19	.21	.19	.17	.19	.17	.16	.17	.15	.14
			H	.25	.23	.21	.23	.21	.20	.21	.19	.18	.18	.17	.16
			G	.28	.26	.24	.24	.23	.21	.22	.21	.19	.20	.18	.18
			F	.30	.28	.25	.27	.25	.23	.24	.22	.21	.21	.20	.19
			E	.33	.31	.29	.30	.27	.26	.26	.24	.23	.23	.21	.20
			D	.36	.33	.31	.32	.30	.28	.28	.26	.25	.24	.23	.22
			C	.38	.35	.32	.33	.31	.29	.29	.27	.26	.25	.24	.23
			B	.40	.37	.35	.35	.33	.32	.30	.29	.28	.26	.25	.24
			A	.41	.39	.37	.37	.34	.33	.31	.30	.29	.27	.26	.25
8 Etched Glass, Ceramic Design, Center Lens	50 30	4 60-W Horizontal; 1 75-W R-30 Flood, Base Up (Total Lumens 4015)	J	.20	.16	.14	.17	.14	.12	.14	.12	.10	.12	.10	.09
			I	.25	.20	.18	.21	.18	.16	.18	.15	.14	.15	.13	.11
			H	.28	.24	.21	.24	.21	.19	.20	.18	.16	.16	.14	.13
			G	.32	.28	.24	.27	.23	.21	.22	.20	.18	.18	.16	.15
			F	.35	.30	.27	.30	.26	.23	.24	.21	.19	.19	.17	.16
			E	.38	.34	.31	.33	.29	.26	.27	.24	.22	.21	.19	.18
			D	.42	.37	.34	.35	.32	.29	.29	.27	.25	.23	.21	.20
			C	.44	.40	.37	.37	.34	.31	.31	.28	.26	.24	.22	.21
			B	.48	.44	.41	.40	.37	.35	.33	.31	.29	.25	.24	.23
			A	.50	.47	.43	.43	.39	.37	.34	.32	.31	.26	.25	.24

TABLE II.—Coefficients of Utilization.

Luminaire	Distribution and Efficiency	Light Sources	Reflectances: Ceiling	75%			50%			30%			10%		
			Walls	50%	30%	10%	50%	30%	10%	50%	30%	10%	50%	30%	10%
			Room Index	Coefficients of Utilization											
9 Opaque Reflector With Suspended Cup, Lens Bottom	0 ↑ — ↓ 30	1 A-21 or A-23, Base Up	J	.17	.16	.15	.17	.16	.15	.17	.16	.15	.16	.16	.15
			I	.20	.20	.19	.20	.19	.19	.20	.19	.18	.19	.19	.18
			H	.22	.21	.21	.21	.21	.21	.21	.21	.20	.21	.21	.20
			G	.23	.23	.22	.23	.22	.22	.22	.22	.22	.22	.22	.22
			F	.24	.24	.23	.24	.23	.23	.24	.23	.23	.23	.23	.23
			E	.25	.25	.25	.25	.25	.24	.25	.24	.24	.24	.24	.24
			D	.26	.26	.26	.26	.26	.25	.26	.25	.25	.25	.25	.25
			C	.27	.27	.26	.27	.26	.26	.26	.26	.25	.26	.25	.25
			B	.28	.27	.27	.27	.26	.26	.27	.26	.26	.26	.26	.26
			A	.28	.28	.27	.27	.27	.26	.27	.26	.26	.26	.26	.26
10 Etched Glass, Ceramic Design	55 ↑ — ↓ 25	3 A-19, Horizontal	J	.20	.16	.14	.16	.14	.12	.13	.10	.10	.11	.09	.08
			I	.24	.20	.18	.20	.17	.15	.17	.14	.13	.13	.11	.10
			H	.27	.24	.21	.23	.20	.18	.19	.16	.14	.14	.13	.12
			G	.31	.27	.24	.26	.23	.20	.21	.18	.17	.16	.14	.13
			F	.34	.30	.26	.28	.25	.22	.22	.20	.18	.17	.15	.14
			E	.37	.34	.30	.32	.28	.26	.25	.22	.21	.19	.17	.16
			D	.41	.37	.34	.34	.31	.28	.27	.25	.23	.20	.19	.18
			C	.43	.39	.36	.36	.33	.30	.28	.26	.24	.21	.20	.19
			B	.46	.43	.40	.39	.36	.34	.30	.28	.27	.22	.21	.20
			A	.49	.45	.43	.41	.38	.36	.32	.30	.28	.23	.22	.21
11 Etched Glass	47 ↑ — ↓ 33	1 A-19 or A-21, Base Up	J	.20	.15	.12	.17	.13	.11	.15	.11	.09	.12	.10	.08
			I	.25	.20	.17	.21	.17	.15	.19	.15	.13	.15	.12	.11
			H	.29	.23	.20	.24	.21	.18	.21	.18	.15	.17	.14	.13
			G	.32	.27	.23	.27	.23	.21	.23	.20	.18	.19	.16	.15
			F	.34	.30	.26	.30	.26	.23	.25	.22	.19	.20	.18	.16
			E	.39	.34	.31	.34	.30	.27	.28	.25	.23	.23	.20	.19
			D	.42	.38	.34	.36	.33	.30	.31	.28	.25	.25	.23	.22
			C	.45	.41	.37	.38	.35	.32	.32	.29	.27	.26	.24	.23
			B	.49	.45	.41	.42	.38	.36	.35	.32	.30	.28	.27	.25
			A	.51	.47	.44	.44	.40	.38	.36	.34	.32	.29	.28	.26
12 Aluminum Bowl, Etched Center Lens	40 ↑ — ↓ 25	1 A-21, Base Up	J	.19	.15	.13	.16	.14	.12	.14	.12	.10	.12	.10	.09
			I	.23	.20	.18	.20	.17	.16	.17	.15	.14	.14	.13	.12
			H	.26	.23	.21	.22	.20	.18	.19	.17	.16	.16	.15	.14
			G	.28	.25	.23	.25	.22	.21	.20	.19	.18	.17	.16	.15
			F	.31	.28	.25	.27	.24	.23	.22	.20	.19	.18	.17	.16
			E	.34	.31	.28	.29	.27	.25	.24	.22	.21	.20	.19	.18
			D	.37	.34	.31	.31	.29	.28	.26	.24	.23	.21	.20	.19
			C	.39	.36	.33	.33	.31	.29	.27	.26	.24	.22	.21	.20
			B	.41	.39	.36	.35	.33	.32	.29	.27	.26	.23	.22	.21
			A	.43	.40	.38	.37	.35	.33	.30	.29	.27	.24	.23	.22

TABLE II.—Coefficients of Utilization.

Luminaire	Distribution and Efficiency	Light Sources	Reflectances											
			Ceiling	75%			50%			30%			10%	
			Walls	50%	30%	10%	50%	30%	10%	50%	30%	10%	50%	30%	10%
			Room Index	Coefficients of Utilization										
13 Etched Glass, Ceramic Design	33 ↑ — ↓ 32	2 A-19, Horizontal	J	.18	.15	.13	.16	.13	.12	.14	.12	.11	.12	.11	.10
			I	.22	.19	.17	.20	.17	.15	.18	.16	.14	.15	.14	.12
			H	.25	.22	.20	.23	.20	.18	.20	.18	.16	.17	.15	.14
			G	.28	.25	.22	.25	.22	.20	.22	.20	.18	.19	.17	.16
			F	.31	.27	.24	.27	.24	.22	.24	.21	.19	.20	.18	.17
			E	.34	.31	.28	.30	.27	.25	.26	.24	.22	.22	.21	.19
			D	.37	.33	.30	.32	.30	.27	.28	.26	.24	.24	.23	.21
			C	.39	.35	.32	.34	.31	.29	.29	.27	.26	.25	.24	.22
			B	.42	.38	.36	.37	.34	.32	.32	.29	.28	.26	.25	.24
			A	.44	.41	.38	.38	.35	.33	.33	.31	.29	.27	.26	.25
14 Etched Glass, Ceramic Design, Round or Square	50 ↑ — ↓ 25	3 A-19, Horizontal	J	.19	.16	.14	.17	.14	.12	.14	.11	.10	.11	.10	.09
			I	.24	.20	.18	.21	.18	.16	.17	.15	.14	.14	.12	.11
			H	.27	.24	.21	.23	.20	.18	.19	.17	.15	.15	.14	.13
			G	.30	.27	.24	.26	.23	.21	.21	.19	.17	.17	.15	.14
			F	.33	.30	.26	.28	.25	.23	.22	.20	.19	.18	.16	.15
			E	.37	.33	.30	.31	.28	.26	.25	.23	.21	.20	.18	.17
			D	.40	.36	.34	.33	.31	.29	.27	.25	.24	.21	.20	.19
			C	.42	.39	.36	.35	.32	.30	.28	.26	.25	.22	.21	.20
			B	.46	.42	.40	.38	.35	.34	.31	.28	.27	.23	.22	.21
			A	.47	.44	.42	.40	.37	.35	.32	.30	.28	.24	.23	.32
15 Etched Glass, Ceramic Design, Round or Square	42 ↑ — ↓ 28	3 to 5 A-19, Horizontal	J	.20	.17	.15	.18	.15	.13	.15	.13	.12	.13	.12	.10
			I	.24	.21	.19	.22	.19	.17	.19	.17	.15	.16	.14	.13
			H	.27	.24	.22	.24	.21	.20	.21	.19	.17	.17	.16	.15
			G	.31	.27	.25	.27	.24	.22	.23	.21	.19	.19	.18	.17
			F	.33	.30	.27	.29	.26	.23	.24	.22	.21	.20	.19	.18
			E	.36	.33	.31	.32	.29	.27	.27	.25	.23	.22	.21	.20
			D	.39	.36	.34	.34	.31	.29	.29	.27	.25	.24	.22	.21
			C	.42	.38	.36	.36	.33	.31	.30	.28	.27	.25	.23	.23
			B	.45	.42	.39	.38	.36	.34	.32	.30	.29	.26	.24	.23
			A	.46	.43	.41	.40	.37	.35	.33	.31	.30	.27	.25	.24
16 Plastic Clip-on Shield	56 ↑ — ↓ 29	1 A-19 or A-21, Base Up	J	.22	.18	.15	.19	.16	.13	.16	.13	.11	.13	.11	.10
			I	.27	.23	.20	.24	.20	.18	.20	.17	.15	.16	.14	.13
			H	.31	.27	.24	.26	.23	.21	.22	.20	.17	.17	.16	.15
			G	.35	.31	.27	.30	.26	.24	.24	.21	.20	.19	.17	.16
			F	.38	.34	.30	.32	.28	.26	.26	.23	.22	.20	.19	.18
			E	.42	.38	.34	.36	.32	.29	.29	.26	.25	.23	.21	.20
			D	.45	.41	.38	.38	.35	.33	.31	.29	.27	.24	.23	.22
			C	.48	.44	.41	.40	.37	.35	.33	.30	.29	.25	.24	.23
			B	.52	.48	.45	.43	.40	.38	.35	.33	.31	.26	.25	.24
			A	.54	.50	.47	.45	.42	.40	.36	.34	.33	.28	.26	.25

TABLE II.—Coefficients of Utilization.

Luminaire	Distribution and Efficiency	Light Sources	Reflectances											
			Ceiling	75%			50%			30%			10%	
			Walls	50%	30%	10%	50%	30%	10%	50%	30%	10%	50%	30%	10%
			Room Index	Coefficients of Utilization											
17 Etched Glass, Center Lens	36 ↑ — ↓ 44	1 A-19, Base Up	J	.20	.15	.13	.19	.14	.12	.16	.13	.11	.14	.12	.10
			I	.25	.20	.17	.23	.19	.16	.21	.17	.15	.18	.15	.13
			H	.29	.24	.21	.26	.22	.19	.24	.20	.17	.20	.17	.16
			G	.33	.28	.24	.29	.25	.22	.26	.22	.20	.23	.19	.18
			F	.36	.31	.26	.32	.28	.24	.28	.25	.22	.25	.21	.20
			E	.40	.36	.31	.36	.32	.28	.32	.28	.25	.27	.25	.23
			D	.44	.39	.34	.39	.35	.31	.35	.31	.28	.30	.28	.26
			C	.47	.42	.37	.42	.37	.34	.37	.33	.31	.32	.29	.28
			B	.51	.46	.42	.45	.41	.38	.39	.36	.34	.34	.32	.30
			A	.53	.49	.45	.47	.43	.40	.41	.38	.36	.35	.33	.32
18 Etched Glass, Ceramic Design, Open Top and Bottom	41 ↑ — ↓ 29	1 to 3 A-19, Base Down	J	.16	.12	.09	.14	.10	.08	.11	.08	.07	.09	.07	.06
			I	.20	.15	.13	.17	.14	.11	.14	.12	.10	.11	.09	.08
			H	.23	.18	.16	.20	.16	.14	.16	.14	.11	.13	.11	.09
			G	.26	.21	.18	.22	.18	.16	.18	.15	.13	.15	.12	.11
			F	.28	.24	.20	.24	.21	.18	.20	.17	.15	.16	.13	.12
			E	.32	.28	.24	.28	.24	.21	.23	.20	.17	.18	.16	.15
			D	.35	.31	.27	.30	.26	.24	.25	.22	.20	.20	.18	.17
			C	.38	.33	.30	.31	.28	.25	.26	.24	.22	.21	.19	.18
			B	.42	.37	.34	.35	.32	.29	.29	.26	.25	.22	.21	.20
			A	.43	.40	.36	.37	.33	.31	.30	.28	.26	.24	.23	.21
19 Etched Glass Chimney	48 ↑ — ↓ 37	1 A-19, Base Down	J	.17	.13	.09	.15	.11	.08	.13	.09	.07	.10	.08	.06
			I	.22	.17	.13	.19	.15	.11	.16	.13	.10	.13	.10	.08
			H	.26	.20	.17	.23	.18	.15	.19	.15	.13	.15	.11	.10
			G	.30	.24	.20	.25	.20	.17	.21	.17	.14	.17	.13	.12
			F	.33	.27	.23	.28	.23	.20	.23	.20	.16	.19	.15	.13
			E	.38	.32	.28	.32	.27	.24	.27	.23	.20	.21	.18	.16
			D	.41	.36	.31	.36	.31	.27	.30	.26	.23	.24	.21	.19
			C	.45	.39	.34	.38	.33	.29	.31	.28	.25	.25	.23	.21
			B	.50	.44	.39	.42	.37	.34	.35	.31	.29	.27	.26	.24
			A	.52	.47	.42	.45	.40	.37	.36	.33	.31	.29	.27	.25
20 Etched Glass, Ceramic Design	26 ↑ — ↓ 44	1 A-19, Base Up	J	.17	.13	.10	.16	.12	.09	.15	.11	.09	.13	.10	.08
			I	.22	.17	.14	.21	.16	.13	.19	.15	.13	.17	.13	.12
			H	.25	.20	.17	.24	.19	.16	.21	.18	.15	.19	.15	.14
			G	.29	.24	.20	.26	.22	.19	.24	.20	.17	.22	.18	.16
			F	.32	.27	.22	.29	.24	.21	.26	.22	.19	.23	.20	.18
			E	.36	.31	.27	.33	.28	.25	.29	.26	.23	.26	.23	.21
			D	.40	.34	.30	.36	.32	.28	.32	.29	.26	.29	.26	.25
			C	.42	.37	.33	.38	.34	.30	.34	.31	.28	.31	.28	.27
			B	.46	.41	.37	.41	.37	.34	.37	.34	.32	.33	.31	.30
			A	.48	.44	.40	.44	.39	.36	.39	.36	.34	.34	.33	.31

TABLE II—Coefficients of Utilization.

Luminaire	Distribution and Efficiency	Light Source	Reflectances											
			Ceiling	70%			50%			30%			10%	
			Walls	50%	30%	10%	50%	30%	10%	50%	30%	10%	50%	30%	10%
			Room Index	Coefficients of Utilization											
21 Etched Glass	13 / 47	2 or 3 A-19, Horizontal	J	.20	.17	.14	.20	.16	.14	.19	.15	.14	.18	.15	.14
			I	.25	.21	.19	.24	.21	.18	.24	.20	.18	.22	.20	.18
			H	.28	.24	.22	.27	.24	.22	.26	.23	.21	.24	.22	.21
			G	.31	.28	.25	.29	.26	.24	.28	.25	.23	.27	.24	.23
			F	.34	.30	.27	.32	.29	.26	.30	.28	.25	.29	.26	.25
			E	.37	.34	.30	.35	.32	.29	.33	.31	.29	.31	.29	.28
			D	.40	.36	.33	.38	.35	.33	.36	.33	.32	.34	.32	.31
			C	.42	.39	.35	.40	.37	.34	.38	.35	.33	.35	.33	.32
			B	.45	.42	.39	.42	.39	.37	.40	.37	.36	.37	.36	.34
			A	.47	.44	.40	.44	.41	.39	.41	.39	.37	.38	.37	.35
22 Opal Glass	10 / 35	2 or 3 A-19, Horizontal	J	.15	.12	.10	.15	.12	.10	.14	.11	.10	.13	.11	.10
			I	.19	.16	.14	.18	.15	.13	.18	.15	.13	.16	.14	.13
			H	.21	.18	.16	.20	.18	.16	.19	.17	.15	.18	.16	.15
			G	.23	.20	.18	.22	.20	.18	.21	.19	.17	.20	.18	.17
			F	.25	.22	.20	.24	.21	.19	.22	.20	.19	.21	.19	.18
			E	.28	.25	.23	.26	.24	.22	.25	.23	.21	.23	.22	.21
			D	.30	.27	.25	.28	.26	.24	.27	.25	.24	.26	.24	.23
			C	.31	.29	.27	.30	.27	.26	.28	.26	.25	.27	.25	.24
			B	.34	.31	.29	.32	.29	.28	.30	.28	.27	.28	.27	.26
			A	.35	.33	.31	.33	.31	.29	.31	.29	.28	.29	.28	.27
23 Etched Glass, Lens Bottom	16 / 44	2 or 3 A-19, Horizontal	J	.20	.16	.14	.19	.16	.13	.19	.15	.13	.17	.15	.13
			I	.25	.21	.19	.24	.20	.18	.23	.20	.18	.21	.18	.17
			H	.27	.23	.22	.26	.23	.21	.25	.22	.20	.23	.21	.20
			G	.30	.27	.24	.29	.26	.23	.27	.24	.23	.25	.23	.22
			F	.33	.29	.26	.31	.28	.25	.29	.26	.24	.27	.25	.23
			E	.36	.33	.10	.34	.31	.29	.32	.29	.27	.30	.28	.26
			D	.39	.36	.33	.37	.34	.32	.35	.32	.30	.33	.30	.29
			C	.41	.38	.35	.38	.35	.33	.36	.34	.32	.34	.32	.30
			B	.44	.41	.38	.41	.38	.36	.38	.36	.34	.35	.34	.33
			A	.46	.43	.40	.43	.40	.38	.39	.37	.36	.36	.35	.34
24 Flashed Opal Glass	38 / 47	1 A-21, A-23, or PS-30, Base Up	J	.24	.19	.16	.22	.18	.15	.20	.16	.14	.17	.15	.13
			I	.30	.25	.22	.27	.23	.20	.25	.21	.19	.22	.19	.17
			H	.34	.29	.26	.31	.27	.24	.27	.24	.21	.24	.21	.19
			G	.38	.33	.29	.34	.30	.27	.30	.27	.24	.27	.24	.22
			F	.41	.36	.31	.37	.33	.29	.33	.29	.27	.29	.26	.24
			E	.45	.41	.36	.41	.37	.33	.36	.33	.30	.32	.29	.28
			D	.49	.44	.40	.44	.40	.37	.39	.36	.33	.35	.32	.31
			C	.52	.47	.43	.46	.42	.39	.41	.38	.35	.36	.33	.32
			B	.56	.51	.48	.50	.46	.43	.44	.41	.39	.38	.36	.35
			A	.59	.54	.50	.52	.48	.45	.45	.43	.41	.39	.38	.36

TABLE II.—Coefficients of Utilization.

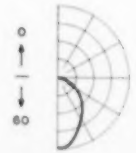
Luminaire	Distribution and Efficiency	Light Sources	Reflectances: Ceiling	75%			50%			30%			10%		
			Walls	50%	30%	10%	50%	30%	10%	50%	30%	10%	50%	30%	10%
			Room Index	Coefficients of Utilization											
25 Metal Ring Louvers	61 / 14	1 PS-25 or PS-30 Silvered Bowl, Base Up	J	.17	.13	.11	.13	.11	.09	.10	.08	.07	.08	.06	.05
			I	.21	.17	.15	.17	.14	.12	.13	.11	.09	.09	.07	.06
			H	.24	.20	.18	.19	.16	.14	.14	.12	.11	.10	.08	.07
			G	.27	.23	.20	.22	.19	.17	.16	.14	.12	.11	.09	.08
			F	.29	.26	.23	.24	.20	.18	.18	.15	.14	.12	.10	.09
			E	.33	.29	.27	.26	.23	.21	.19	.17	.16	.13	.11	.11
			D	.36	.33	.30	.28	.26	.24	.21	.19	.18	.14	.13	.12
			C	.38	.35	.32	.30	.27	.26	.22	.20	.19	.15	.13	.12
			B	.42	.39	.36	.33	.31	.29	.24	.22	.21	.15	.14	.13
			A	.44	.40	.38	.35	.32	.30	.25	.24	.22	.16	.15	.14
26 White Metal Reflector	 0 / 60	1 PS-25 or PS-30 Silvered Bowl, Base Up	J	.30	.26	.24	.29	.26	.24	.29	.26	.24	.29	.26	.24
			I	.37	.34	.32	.36	.33	.31	.36	.33	.31	.35	.32	.31
			H	.40	.37	.35	.39	.37	.35	.38	.37	.35	.37	.36	.35
			G	.43	.40	.38	.42	.40	.38	.41	.39	.38	.40	.39	.38
			F	.45	.43	.40	.44	.42	.40	.43	.41	.40	.42	.41	.40
			E	.48	.46	.44	.47	.46	.44	.47	.45	.44	.46	.45	.44
			D	.52	.49	.47	.50	.49	.47	.50	.48	.47	.49	.47	.46
			C	.53	.51	.49	.52	.50	.49	.51	.49	.48	.50	.49	.47
			B	.55	.53	.51	.53	.52	.51	.53	.51	.50	.52	.50	.49
			A	.56	.54	.52	.55	.53	.52	.54	.52	.51	.53	.51	.50
27 Semi-Recessed, White Reflector, Metal Louvers	0 / 60	1 PS-30 Silvered Bowl, Base Up	J	.32	.29	.27	.31	.29	.27	.31	.29	.26	.31	.28	.26
			I	.38	.36	.35	.38	.35	.34	.38	.35	.33	.36	.34	.33
			H	.41	.40	.38	.41	.39	.38	.40	.39	.38	.39	.38	.38
			G	.44	.43	.41	.44	.42	.41	.42	.41	.41	.41	.41	.41
			F	.47	.45	.43	.45	.44	.43	.45	.44	.43	.44	.44	.43
			E	.49	.48	.46	.49	.47	.46	.48	.47	.46	.47	.47	.46
			D	.53	.50	.49	.52	.49	.48	.51	.49	.48	.50	.49	.48
			C	.54	.52	.50	.53	.51	.50	.52	.50	.49	.51	.50	.49
			B	.55	.53	.52	.54	.52	.52	.53	.52	.51	.52	.51	.50
			A	.56	.55	.53	.55	.53	.53	.55	.53	.52	.53	.52	.51
28 Recessed, Diffusing Glass Cover	0 / 40	1 A-21, Horizontal	J	.20	.18	.16	.20	.18	.16	.20	.17	.16	.19	.17	.16
			I	.24	.22	.21	.24	.22	.21	.24	.22	.21	.23	.22	.21
			H	.26	.25	.24	.26	.25	.24	.26	.24	.24	.25	.24	.24
			G	.28	.27	.26	.28	.27	.26	.27	.26	.26	.27	.26	.26
			F	.30	.28	.27	.29	.28	.27	.29	.28	.27	.28	.28	.27
			E	.32	.31	.29	.32	.30	.29	.31	.30	.29	.31	.30	.29
			D	.34	.33	.32	.34	.32	.32	.33	.32	.31	.33	.32	.31
			C	.35	.34	.33	.35	.33	.33	.34	.33	.32	.34	.33	.32
			B	.36	.35	.34	.36	.34	.34	.35	.34	.33	.34	.34	.33
			A	.37	.36	.35	.36	.35	.35	.36	.35	.34	.35	.34	.34

TABLE II—Coefficients of Utilization.

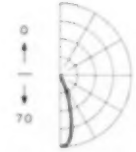
Luminaire	Distribution and Efficiency	Light Source	Reflectances: Ceiling	75%			50%			30%			10%		
			Walls	50%	30%	10%	50%	30%	10%	50%	30%	10%	50%	30%	10%
			Room Index	Coefficients of Utilization											
29 Recessed, Metal Louvers	 0 / 70	1 150-W PAR-38 Flood, Base Up (1850 Lumens)	J	.40	.38	.36	.39	.38	.36	.39	.38	.36	.39	.38	.36
			I	.48	.46	.45	.47	.46	.45	.46	.46	.43	.46	.45	.43
			H	.51	.50	.50	.50	.50	.49	.50	.50	.48	.49	.49	.48
			G	.55	.54	.53	.53	.52	.52	.52	.52	.51	.52	.52	.51
			F	.57	.56	.55	.55	.55	.54	.55	.55	.53	.55	.55	.53
			E	.60	.59	.58	.59	.58	.57	.58	.57	.56	.57	.57	.56
			D	.63	.61	.60	.62	.60	.59	.61	.59	.59	.60	.59	.59
			C	.64	.63	.61	.63	.61	.60	.62	.60	.60	.61	.60	.59
			B	.65	.64	.63	.64	.62	.61	.63	.62	.61	.62	.61	.60
			A	.66	.65	.64	.64	.63	.62	.64	.62	.62	.62	.62	.61
30 Recessed, Specular Reflector	0 / 40	1 A-23 or PS-25 Silvered Bowl, Base Up	J	.23	.22	.21	.22	.22	.21	.22	.22	.20	.22	.22	.20
			I	.27	.26	.26	.27	.26	.26	.26	.26	.25	.26	.26	.25
			H	.29	.29	.28	.29	.28	.28	.29	.28	.28	.28	.28	.28
			G	.31	.31	.30	.31	.30	.30	.30	.30	.29	.30	.30	.29
			F	.33	.32	.31	.32	.31	.31	.32	.31	.30	.32	.31	.30
			E	.34	.34	.33	.34	.33	.32	.33	.33	.32	.33	.32	.32
			D	.36	.35	.34	.35	.34	.33	.34	.34	.33	.34	.34	.33
			C	.37	.36	.35	.36	.35	.34	.35	.34	.34	.35	.34	.34
			B	.37	.36	.36	.36	.36	.35	.36	.35	.35	.35	.35	.34
			A	.38	.37	.36	.37	.36	.36	.36	.36	.35	.36	.35	.35
31 Bare-Lamp Unit, White Reflector	26 / 59	1 Circline F	J	.27	.22	.18	.26	.21	.18	.24	.20	.17	.22	.19	.17
			I	.34	.29	.26	.32	.27	.24	.31	.26	.23	.28	.24	.22
			H	.38	.33	.30	.36	.32	.28	.34	.30	.27	.31	.27	.26
			G	.43	.37	.33	.39	.35	.32	.36	.33	.30	.34	.31	.29
			F	.46	.40	.36	.42	.38	.35	.39	.35	.33	.36	.33	.31
			E	.51	.46	.42	.47	.43	.39	.43	.40	.37	.40	.37	.36
			D	.55	.50	.46	.51	.47	.44	.47	.44	.41	.44	.41	.39
			C	.57	.53	.49	.53	.49	.46	.49	.46	.43	.45	.43	.41
			B	.62	.57	.53	.57	.53	.50	.52	.49	.47	.47	.46	.44
			A	.64	.60	.56	.59	.55	.52	.54	.51	.49	.49	.47	.46
32 Etched Pebbled Glass	44 / 36	1 Circline F	J	.22	.18	.15	.20	.16	.14	.17	.14	.12	.15	.13	.11
			I	.28	.23	.21	.25	.21	.19	.22	.19	.17	.18	.16	.15
			H	.31	.27	.24	.28	.24	.22	.24	.21	.19	.20	.18	.17
			G	.35	.31	.27	.31	.27	.25	.26	.23	.22	.22	.20	.19
			F	.38	.33	.30	.33	.29	.27	.28	.25	.24	.24	.22	.21
			E	.42	.38	.34	.37	.33	.30	.31	.28	.27	.26	.24	.23
			D	.45	.41	.38	.40	.36	.34	.34	.31	.30	.29	.27	.25
			C	.48	.44	.40	.41	.38	.36	.35	.33	.31	.30	.28	.26
			B	.52	.48	.45	.44	.41	.39	.38	.35	.34	.31	.30	.29
			A	.53	.50	.47	.47	.43	.41	.39	.37	.35	.32	.31	.30

TABLE II.—Coefficients of Utilization.

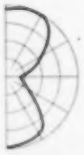
Luminaire	Distribution and Efficiency	Light Sources	Reflectances: Ceiling	75%			50%			30%			10%		
			Walls	50%	30%	10%	50%	30%	10%	50%	30%	10%	50%	30%	10%
			Room Index	Coefficients of Utilization											
33 Etched Glass, Ceramic Design	50 / 35	4 Lamps, F	J	.26	.22	.20	.22	.20	.18	.20	.18	.16	.17	.16	.14
			I	.31	.27	.25	.28	.25	.23	.24	.22	.20	.21	.19	.18
			H	.35	.31	.29	.31	.28	.26	.27	.25	.23	.22	.21	.20
			G	.39	.35	.32	.34	.31	.29	.29	.27	.25	.25	.23	.22
			F	.42	.38	.35	.36	.33	.31	.31	.29	.27	.26	.25	.24
			E	.45	.42	.39	.40	.37	.34	.34	.31	.30	.28	.27	.26
			D	.49	.45	.42	.43	.40	.37	.36	.34	.33	.30	.29	.28
			C	.52	.48	.45	.44	.42	.39	.37	.35	.34	.31	.30	.29
			B	.55	.51	.49	.47	.44	.43	.40	.37	.36	.32	.31	.30
			A	.57	.54	.51	.49	.46	.44	.41	.39	.37	.33	.32	.31
34 Etched Glass, Ceramic Design	29 / 46	3 Lamps, F	J	.25	.21	.18	.23	.19	.17	.21	.18	.16	.19	.17	.15
			I	.30	.26	.24	.28	.25	.22	.26	.23	.21	.24	.21	.20
			H	.34	.30	.27	.31	.28	.26	.29	.26	.24	.26	.24	.23
			G	.37	.33	.31	.34	.31	.29	.31	.29	.27	.28	.26	.25
			F	.40	.36	.33	.36	.33	.31	.34	.31	.29	.30	.28	.27
			E	.44	.40	.37	.40	.37	.34	.37	.34	.32	.33	.31	.30
			D	.47	.43	.40	.43	.40	.37	.40	.37	.35	.36	.34	.33
			C	.50	.46	.42	.45	.42	.39	.41	.38	.36	.37	.35	.34
			B	.53	.49	.46	.48	.45	.43	.43	.41	.39	.38	.37	.36
			A	.55	.51	.49	.50	.47	.44	.45	.42	.41	.40	.38	.37
35 Diffusing White Plastic Shield	12 / 53	2 Lamps, F	J	.24	.20	.18	.24	.20	.18	.23	.19	.17	.22	.19	.17
			I	.30	.26	.24	.29	.25	.23	.28	.25	.22	.27	.24	.23
			H	.33	.30	.27	.32	.29	.27	.31	.28	.26	.29	.27	.26
			G	.36	.33	.30	.35	.32	.30	.33	.30	.29	.32	.30	.28
			F	.39	.36	.32	.37	.34	.32	.36	.33	.31	.34	.32	.30
			E	.43	.40	.36	.41	.38	.35	.39	.36	.34	.37	.35	.34
			D	.46	.42	.40	.44	.41	.39	.42	.39	.38	.40	.38	.37
			C	.48	.45	.41	.45	.43	.40	.43	.41	.39	.41	.39	.38
			B	.51	.48	.45	.48	.45	.43	.46	.43	.42	.43	.41	.40
			A	.52	.49	.47	.50	.46	.45	.47	.45	.43	.44	.43	.41
36 Diffusing Plastic Side Panels, Metal Louvers	45 / 35 	2 or 4 Lamps, F	J	.25	.22	.20	.22	.20	.18	.20	.18	.16	.18	.17	.15
			I	.31	.27	.26	.28	.25	.23	.24	.22	.21	.21	.20	.18
			H	.34	.31	.29	.30	.28	.26	.27	.25	.23	.23	.22	.21
			G	.38	.35	.32	.34	.31	.29	.29	.27	.26	.25	.24	.23
			F	.41	.38	.34	.36	.33	.31	.31	.29	.27	.27	.25	.24
			E	.44	.41	.38	.39	.36	.34	.33	.31	.30	.28	.27	.26
			D	.48	.44	.42	.42	.39	.37	.36	.34	.33	.30	.29	.28
			C	.50	.47	.44	.43	.41	.39	.37	.35	.34	.31	.30	.29
			B	.53	.50	.47	.46	.43	.42	.39	.37	.36	.32	.31	.30
			A	.55	.52	.50	.48	.45	.43	.40	.38	.37	.33	.32	.31

TABLE II.—Coefficients of Utilization

Luminaire	Distribution and Efficiency	Light Sources	Reflectances											
			Ceiling	75%			50%			30%			10%	
			Walls	50%	30%	10%	50%	30%	10%	50%	30%	10%	50%	30%	10%
			Room Index	Coefficients of Utilization											
37 Bare-Lamp Unit, White Reflector	22 / 63	2 or 4 Lamps, F	J	.29	.23	.20	.28	.23	.19	.26	.21	.19	.25	.21	.18
			I	.36	.31	.27	.34	.29	.26	.33	.28	.25	.30	.27	.25
			H	.40	.35	.32	.38	.34	.31	.36	.32	.29	.32	.30	.28
			G	.44	.39	.35	.42	.37	.34	.39	.35	.33	.37	.73	.72
			F	.48	.43	.38	.45	.40	.37	.42	.38	.36	.39	.36	.34
			E	.53	.48	.44	.50	.45	.42	.46	.43	.40	.43	.40	.39
			D	.57	.52	.48	.53	.50	.46	.50	.47	.44	.47	.44	.43
			C	.59	.55	.51	.55	.52	.49	.52	.49	.47	.49	.46	.44
			B	.64	.59	.56	.59	.55	.53	.55	.52	.50	.52	.49	.48
			A	.66	.62	.58	.61	.58	.55	.57	.54	.52	.53	.51	.49
38 White Metal Reflector	0 / 80	2 Lamps, F	J	.37	.32	.28	.37	.32	.28	.36	.31	.28	.36	.31	.28
			I	.46	.41	.38	.45	.40	.37	.45	.40	.37	.44	.40	.37
			H	.50	.46	.43	.49	.46	.43	.48	.45	.43	.47	.44	.43
			G	.54	.50	.47	.53	.50	.47	.52	.48	.47	.51	.48	.47
			F	.57	.53	.50	.56	.52	.50	.55	.52	.50	.54	.52	.50
			E	.62	.59	.56	.61	.58	.56	.60	.57	.56	.60	.57	.56
			D	.67	.64	.60	.65	.63	.60	.64	.62	.60	.64	.61	.60
			C	.68	.66	.63	.67	.64	.63	.66	.64	.62	.65	.63	.61
			B	.72	.69	.67	.70	.68	.66	.69	.67	.65	.68	.66	.64
			A	.73	.71	.68	.72	.69	.68	.71	.68	.67	.69	.68	.66
39 Semi-Recessed, Diffusing White Plastic Shield	2 / 63	2 Lamps, F	J	.30	.26	.24	.30	.26	.24	.29	.26	.24	.29	.26	.24
			I	.37	.34	.31	.36	.33	.31	.36	.33	.31	.35	.32	.31
			H	.40	.37	.35	.40	.37	.35	.39	.37	.35	.37	.36	.35
			G	.43	.40	.38	.43	.40	.38	.41	.39	.38	.41	.39	.38
			F	.46	.43	.40	.45	.42	.40	.44	.42	.40	.43	.41	.40
			E	.49	.47	.44	.49	.46	.44	.48	.45	.44	.47	.45	.44
			D	.53	.50	.48	.52	.49	.48	.51	.49	.48	.50	.48	.47
			C	.55	.52	.49	.53	.51	.49	.52	.50	.49	.51	.49	.48
			B	.57	.54	.53	.55	.53	.52	.54	.52	.51	.53	.51	.51
			A	.58	.56	.54	.57	.54	.53	.56	.53	.52	.54	.53	.51
40 Recessed, Diffusing Glass Cover	0 / 55	2 Lamps, F	J	.28	.24	.22	.27	.24	.22	.27	.24	.22	.26	.24	.22
			I	.34	.31	.29	.33	.30	.29	.33	.30	.29	.32	.30	.29
			H	.36	.34	.32	.36	.34	.32	.35	.34	.32	.34	.33	.32
			G	.39	.37	.35	.38	.37	.35	.37	.36	.35	.37	.36	.35
			F	.41	.39	.37	.40	.38	.37	.40	.38	.37	.39	.38	.37
			E	.44	.42	.40	.43	.42	.40	.43	.41	.40	.42	.41	.40
			D	.47	.45	.43	.46	.45	.43	.46	.44	.43	.45	.43	.42
			C	.48	.47	.45	.47	.46	.45	.47	.45	.44	.46	.45	.43
			B	.50	.48	.47	.49	.47	.47	.48	.47	.46	.47	.46	.45
			A	.52	.49	.48	.50	.48	.47	.49	.48	.47	.48	.47	.46

of the individual unit tested was not representative of the general type of luminaire, the efficiency was adjusted to what was believed to be a more typical value. In accordance with general Society practice in publishing data of this nature, all efficiencies have been rounded off to the nearest 5 per cent. For most of the types of fixtures tested, lamp size does not significantly affect distribution and efficiency, and therefore specific lamp wattages have not been indicated in the table. In three special cases (luminaire 8, which uses a reflector lamp in combination with A-bulb lamps, and 6 and 7, each of which has one of its lamps located over a center lens) the candlepower distribution and efficiency would be altered by changes in the wattage of the lamps. For these three luminaires the distribution, efficiency, and coefficients of utilization shown apply only for the lamp wattages listed in the "Light Sources" column.

A few luminaires of relatively concentrating distribution, most of them designed primarily for use over a dining table, are to be found in Table II (for example, numbers 6, 7, 8, 9, 29, and 30). It should be noted that for residential equipment with strong concentrating downward components a coefficient of utilization, expressing *average* illumination on a 30- to 36-inch plane throughout the room, has little meaning. If such a fixture is placed over a table the illumination on the table will be much higher than the average value calculated by the lumen method, and in other parts of the room much lower. Where there is no upward light the footcandles to be expected in various locations in the room may be more accurately determined by the point-by-point method.

In using Table II, as in using any other coefficient of utilization table, it is possible to arrive at erroneous conclusions by selecting a luminaire on the basis of appearance alone. Two fixtures which superficially look much alike may vary considerably in efficiency and candlepower distribution, depending on the transmitting and reflecting properties of glass or plastic, the efficiency of other reflecting surfaces, position of lamps, size of canopy, and so on. Especially is this true of recessed equipment, where the inner construction is not immediately obvious. It is not necessary that the fixture under consideration have exactly the same material or the same type of finish as is specified for the fixture selected from the table; if the lighting characteristics are similar, the coefficients of utilization may be applied. If the luminaire is known to have a distribution like one of those shown in the table, but to be significantly different in efficiency, the coefficients can readily be adjusted in the ratio of the two efficiencies. Where no photometric data are available, selection from the table should be carefully made, with due consideration to all the known factors.

As in any illumination calculations, it is necessary to remember that the result obtained applies strictly to an empty room, with ceiling, walls, and floor of the reflectances specified. In general, the presence of furniture and other objects in a room tends to lower the average illumination level. Wall reflectance must be judged not by the value of the paint or wallpaper alone, but on the basis of the *average* reflectance of all wall area, considering furniture as well as window and door openings. The average reflectance of the floor (floor covering and furniture) should be taken into consideration if it varies greatly from 14 per cent (see above).

One important factor, maintenance, has been altogether omitted from consideration in Table II. It must be strongly emphasized that the results obtained by the use of the data will be *initial* values only, with new lamps and clean equipment. To the best of the authors' knowledge, no specific maintenance information on home lighting equipment is available, and conditions vary so greatly that it seems futile to hazard any percentage estimates. Maintenance of room surfaces in the home is ordinarily such that changes in their reflectance can probably be neglected. However, lamps do depreciate, fixtures do collect dirt — particularly in the kitchen — and certain luminaire reflecting surfaces gradually deteriorate. Allowance for these factors must be made in estimating *in-service* footcandles.

Conclusion

Some limitations will always be inherent in applying the lumen method to calculations of illumination in the home. Because of the variable colors and patterns in wall treatments, fabrics, and floor coverings, and because of the small and often irregularly shaped rooms in which the effect of door and window areas is relatively great, it is more difficult to make accurate predictions than in a schoolroom or a large office. To the ultimate consumer, luminaire efficiency and light distribution may never be as important in the selection of fixtures for the home as styling, appearance, and personal preference. However, it is the hope of the authors that the information presented here may prove a useful guide to the illuminating engineer and lighting specialist confronted with the problem of determining the fixture capacity required for specified general lighting levels in various residential interiors.

Acknowledgments

The authors wish to express their appreciation to J. R. Jones of the Commercial Engineering Department for his helpful suggestions in connection with this study. They also gratefully acknowledge the assistance of the following manufacturers in supplying equipment for test: Gill Glass and Fixture Co., Globe Lighting Products, Inc., Gruber Brothers, Inc., Imperial Lighting Products Co., Lighting Specialties, Lightolier, Moe Light, Inc., Rambusch Decorating Co., Sears, Roebuck and Co., and Silvray Lighting, Inc.

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Modern Lighting for a Modern Bathroom

General illumination in this modern bathroom is provided by two 72" slimline lamps recessed in the ceiling and glass shielded. At the lavatory (in photo left), the level is 60 footcandles at face height, with two-lamp 30-watt fluorescent units over the bowl. The medicine cabinets have 75-watt recessed and shielded incandescent lamps.

At the tooth basin (shown in other photo) the level is 40 footcandles provided by 100-watt incandescent lamps in a recessed unit, half inside and half outside mirror, controlled by switch beside door. Behind the mirror is storage space for dental needs. Lighting inside the linen closet is supplied by 15-watt T-12 fluorescent lamps. The walls, ceiling and floor are light blue.

Photo courtesy of Detroit Edison Co., Detroit, Mich.

The Evaluation of Visual Comfort Data

Additional Discussion and Rebuttal on paper by H. L. Logan and A. W. Lange

(Published April 1952 issue of ILLUMINATING ENGINEERING, pp. 195-205)

DOMINA EBERLE SPENCER*: The authors of this paper are to be congratulated on their understanding of two important visual facts. The *luminous environment* in a room is of supreme importance in lighting. We are all realize this fact today. But in the past, too many formulations of the glare problem have ignored the basic facts of visual processes.

1. The first trouble with previous glare rating systems has been that the data cover too *small a range*. One to 100 ft-c is not enough. The eye adapts itself over a very wide range; and to predict its behavior we must make our graphical or mathematical formulation cover a similar range. All the Nela Park data cover a very narrow range of brightnesses. Moreover, the data have been represented by straight lines and rashly extrapolated — with meaningless results. Logan and Lange guard against this weakness. At long last, the straight lines have been eliminated.

2. The second weakness in previous glare ratings has been the *neglect of the state of adaptation*. A value of brightness that is glaring at night may be almost unnoticeable in the daytime. The Harrison glare rating system suffers particularly from this fault. As a result it predicts that an overcast sky would be intolerable. It also says that a completely uniform room with high illumination would be glaring. Such predictions are not in accord with experiment. Logan and Lange recognize the importance of adaptation brightness and have gone further than their predecessors toward a correct use of this basic visual concept.

But what is the purpose of this and other glare papers? Evidently we want a simple criterion which will allow us to predict whether a proposed lighting installation will be satisfactory or not. If you want the simplest criterion, take the 3:1 ratio. It is easy to apply and it is a safe criterion. If nothing in the room has a brightness of more than three times the adaptation brightness, visual conditions will be excellent. We can achieve the 3:1 ratios by using luminous ceilings or by luminous indirect luminaires.

For these types of lighting, the 3:1 ratio is necessary and sufficient. Of course, if one is required to sell small sources of high brightness, he can never satisfy the 3:1 ratio. In such cases, one must make a more detailed analysis of the relation between source size and allowable brightness. This is the purpose of the Logan and Lange paper. The point I wish to emphasize, however, is that with the best types of lighting, we do not need the complicated analysis of the Logan and Lange paper.

There is just one other point on which I should like to comment. Our formula for adaptation brightness *does* weight the fovea very heavily, as Logan and Lange say, but this is what the experiment says. It is not an extrapolation. Note also that this heavy weighting of the fovea applies only when the eyes are focused on the glare source long enough to adapt to this visual field. If the glare source is not steadily imaged on the fovea, the adaptation brightness is determined largely by the extrafovea.

*University of Connecticut, Storrs, Conn.

The authors seem to be a little careless in their use of the concept of adaptation brightness. We can calculate it for many different situations for the eyes adapted to the work or for eyes roving at random over the visual field. At any instant there is a state of adaptation of the eyes which depends upon what we have been doing with them in the past. Visual theory predicts quite different responses to glare sources for different states of adaptation. If the authors would be more precise in stating what the eyes were assumed to be adapted to in a given investigation, the discrepancies which bother them would vanish.

To summarize, if we have good lighting systems the complicated analysis of Logan and Lange is not needed. The simple 3:1 ratio is sufficient. But if we have glare sources in our rooms, then the Logan and Lange graph seems to be a great advance over previous methods of analysis.

H. L. LOGAN and A. W. LANGE*: The authors appreciate Dr. Spencer's discussion and thank her for her judgment that "the Logan and Lange graph seems to be a great advance over previous methods of analysis" (of) "glare sources." That was the purpose of the paper.

We regret that Dr. Spencer should confuse the discussion with the gratuitous statement that "Evidently we want a simple criterion"; and we also regret the unwarranted implication in her statement, "Of course, if one is required to sell small sources of high brightness, he can never satisfy the 3:1 ratio."

Speaking for ourselves we are not interested in a "simple," nor a complex criterion as such. We are interested in the truth — as much of the truth as we can discover. If the truth turns out to be complex we cannot, with all due regard to Dr. Spencer's interests, feelings and desires, twist it into a simple 3 to 1 ratio. The statement is often made that "truth is simple," but scientific investigation of natural phenomena has developed the fact that natural truth is complex. The truths about the inter-action of man's nervous system with natural phenomena are highly complex. The most just criticism of our evaluation of data in our paper that could be made is that we have over-simplified a very complex series of relationships. To carry this simplification process to the point of coming out with one ratio — the "3 to 1" ratio — is a reductio ad absurdum.

With reference to the comment about being "required to sell small sources of high brightness" we doubt that the research workers that gathered the data were ever under this compulsion. The fact that the data show that under the proper conditions "small sources of high brightness" can be comfortable is simply a reflection of the data; and agrees with common observation.

The desire to substitute one blanket ratio would prevent the individual engineer from working out a solution that fits all the conditions of a job best; and would deprive the user of the opportunity to adopt the most economical solu-

*Authors: Holophane Co., New York, N. Y.

tion. It can be likened to the refrigerator industry agreeing that, because there are some ten children families, a 30-cubic foot refrigerator should be adopted universally for domestic use. An examination of the visual comfort chart will show that 3 to 1 ratios become necessary at high adaptation levels when the light sources approach 20% of the field of view in size; but at lower adaptation levels, and with smaller light sources, ratios that indicate the same condition of comfort can run 70 to 1 or higher. In fact, if there is one thing that changes more rapidly than any other factor from one side of the comfort chart to the other, it is the ratios. It hardly seems reasonable to blithely telescope all these ratios into one, and then use that as a criterion for lighting.

We are glad to see Dr. Spencer emphasize again the fact that "if the glare source is not steadily imaged on the fovea, the adaptation brightness is determined largely by the extrafovea." Connected with this is the fact, pointed out by Marshall and Talbot,[1] and Moon and Spencer,[2] that adaptation is another "range" phenomenon. That is, that in a non-uniform field eye movements do not necessarily cause significant transient effects in adaptation. According to Marshall and Talbot adaptation tends to remain essentially stable through brightness swings of "2 log units." In other words people occupying a work place do not necessarily experience continual, or even any change in their adaptation, nor "shock" when their eyes involuntarily pass a lighting unit. When the changes of brightness people encounter are within the "range" limit for the given interior their adaptation does not sensibly fluctuate.

An important piece of research still needed is one that will determine this range of stability for each adaptation level.

1. W. H. Marshall and S. A. Talbot, Recent Evidence for Neural Mechanisms in Vision Leading to a General Theory of Sensory Acuity," Biological Symposia, Vol. VII, p. 120, Jacques Cattell Press.

2. P. Moon and D. E. Spencer, The Specification of Foveal Adaptation, J.O.S.A., Vol. 33, No. 8, p. 453, August 1943.

Luminous Ceiling Demonstrated in Model Kitchen

This kitchen of a model home uses corrugated white translucent acrylic, mounted on a simple frame, below the fluorescent lamps to provide diffuse general lighting of about 30 footcandles. The luminous area is 4 feet three inches by 8 feet 3 inches and the T-8 30-watt 4500K lamps are mounted 10 inches above the three plastic panels, on 12-inch centers. *Photograph courtesy Rohm and Haas Co., Philadelphia, Pa.*

INSTALLATION ON BISCAYNE BOULEVARD, MIAMI, FLORIDA.

Lighting a Boulevard

LIGHTING OBJECTIVE: To provide light of white-way proportions on the two outer traffic lanes of a 4-lane boulevard, using the spill light from the luminaires to illuminate the two inner lanes adequately for parking.

GENERAL INFORMATION: This section of Biscayne Boulevard, extending from Southeast Second Street to Northeast Second Street, is the most important boulevard and traffic street section in Miami. Not only is this 200-foot-wide area heavily traveled by tourists, but it is also the site of major civic pageants and parades.

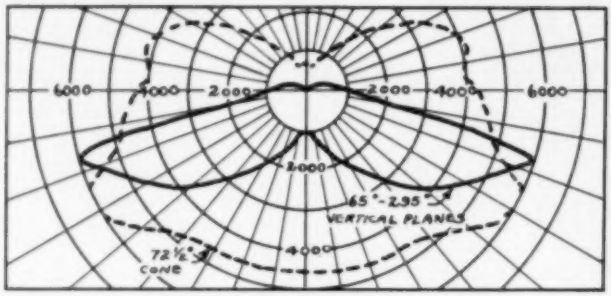
LIGHTING INSTALLATION: The relighted section of the boulevard is illuminated by 48 General Electric Form 108 luminaires using 25,000-lumen 20-ampere series filament lamps mounted 29 feet above the roadway on 8-foot brackets. The spacing is 120 feet staggered (240 feet along each curb).

Existing pole bases, on which the old shafts were replaced by new octagonal shafts of special Union Metal Company manufacture, were utilized. These shafts were designed to withstand 170-mile-an-hour hurricane winds.

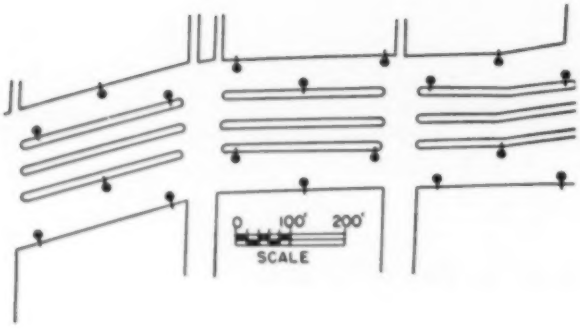
This system provides an average calculated initial illumination on the traffic lanes of approximately 1.4 footcandles. Calculations show that these units should provide initially 0.75 footcandles spill light on the two inner parking lanes.

(over)

A.I.A. File No. 31-J



Left, close-up of luminnaire, 21 inches in diameter and almost a yard high. Right, candlepower distribution curve.



Plan view showing luminaire layout over traffic lanes; spill light provides adequate illumination for parking lanes in center.

Lighting planned by R. M. Swetland, Assistant Manager of the Illuminating Laboratory, Lighting Division, General Electric Company.

Lighting data submitted by R. M. Swetland and R. J. Swackhamer, General Electric Company, West Lynn, Mass., as an illustration of good lighting practice and to aid in the design of similar installations.

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Work, Vision and Illumination

By ERNST SIMONSON
JOSEF BROZEK

CRITICAL seeing has assumed major importance in the occupational activity of a large number of industrial workers. The importance of vision for clerical occupations is obvious. The increasing involvement of visual functions in man's work and the frequent complaints about eye strain and fatigue are directing the interest of several groups of specialists (ophthalmologists, physiologists, psychologists, and illuminating engineers) to questions of illumination and vision. Nevertheless, the advancement of knowledge in this area has been less satisfactory than one might have expected.

On May 20-21, 1939, the National Research Council arranged a conference on visual fatigue[1] with A. Ames, Jr., A. Bielschowsky, P. W. Cobb, W. F. Dearborn, D. B. Dill, C. H. Graham, S. Hecht, H. M. Johnson, R. A. McFarland, W. R. Miles, F. K. Moss, P. G. Nutting, B. O'Brien, I. Stewart, M. A. Tinker, and G. Wald participating. The representation of psychological, physiological, ophthalmological and physical competence could not have been better. There was an agreement that, in spite of the extensive research on vision, no satisfactory method for measuring visual fatigue existed at that time and that even a precise and workable definition of visual fatigue was lacking. G. Wald suggested, for this reason, that "we might apply ourselves to the simpler and more feasible task of measuring the optimal conditions for visual performance." Naturally, one must ask, which criteria should be used to determine the optimal conditions for visual work? It seems that the task suggested by G. Wald is not any simpler than the question of visual fatigue but leads back to the fundamental problem of how to measure visual performance and visual fatigue. This was, indeed, the conclusion reached after a prolonged discussion and summarized by the chairman, W. R. Miles, at the end of the conference: "Our consensus of opinion seems to be that several of these methods (which were suggested for visual fatigue studies) should be combined into a test battery for use in any single investigation that undertakes to measure visual fatigue in connection with any particular work task. We need comparative results on different tests applied to the same subject personnel following given visual work routines. The general picture obtained from a battery of tests by being more comprehensive and sampling the performance of various types of eye mechanisms should provide the basis for later evaluation of the efficacy of individual tests. Experimentation in this field should not neglect the important datum of subjective report and it must be remembered that motivation is a crucial element in most visual work that is continued for long periods of time."

To our knowledge, no comprehensive study of such type has been undertaken before the conference on visual fatigue (1939). Yet illumination codes, suggesting or, at least, implying, optimum conditions of illumination for various job categories were available long before that time. In the absence of satisfactory methods for measuring visual work and fatigue the very basis of the illumination codes appears to be open to question. Nevertheless, for a period of about 25 years the illumination codes were not challenged. It was only after the Washington conference on visual fatigue that the basis of the illumination codes has come under more critical scrutiny.

It seems that the time has arrived to re-examine the present situation, the progress which has been made since 1939, and the possibility of re-evaluating the older material in the light of the recent progress. This is the purpose of the present article. However, it is not intended to be a complete review of the literature and the various approaches which have been used for the study of visual work and illumination will be illustrated by reference to selected studies.

Trends in Illumination Codes

It is generally agreed that variations of the illumination level produce greater changes in visual performance or visual comfort than can be obtained by variation of other variables, such as the spectral quality of light. Therefore, providing proper illumination levels must be considered a crucial step in securing optimum efficiency in work involving vision. It is justified that the illumination codes are mainly concerned with the level of illumination

A paper presented at the National Technical Conference of the Illuminating Engineering Society, August 27-30, 1951, Washington, D. C. Authors: Laboratory of Physiological Hygiene, University of Minnesota, Minneapolis, Minn.

or, preferably, the reflected brightness, which also takes into consideration the contrast between the critical details and the background. In comparing the earlier illumination codes with the more recent ones one find a striking increase in the illumination levels recommended for the same type of jobs. For example, for ordinary reading; 30 footcandles are recommended now[2] as compared with 3 to 6 footcandles 30 years ago.[3]

In 1910 Wickenden[4] classified illumination requirements into three groups: low, below one footcandle (for shops and ware rooms); medium, from 1 to 4 footcandles (for office desks, reading tables, libraries, school rooms); and high, in excess of 4 footcandles (for jobs requiring discrimination of fine details). In "Light; Its Use and Misuse, A Primer of Illumination," prepared under the direction of the Illuminating Engineering Society,[5] published 1912, it was stated that "ordinary reading, writing, or work on white or light-colored material can comfortably be carried on by most people with an illumination of 2 to 3 footcandles." In the "Code for Lighting for Factories, Mills, and Other Work Places" published by the United States Public Health Service in 1919,[6] 4 to 8 footcandles for office work were recommended, which was advanced to 5 to 10 footcandles in the "American Standard Code of Lighting," of the Illuminating Engineering Society, 1922.[7] For class rooms and study rooms 3 to 6 footcandles were recommended in 1917 by the Illuminating Engineering Society,[3] compared to 8 footcandles and higher in the School Lighting Code of the State of Wisconsin, 1921.[8]

Is the increase in the recommended illumination level due to an improvement in the sensitivity of the methods used as basis for the recommendations? This is undoubtedly the case in some instances, but closer examination of some original papers (Freeman[9]) does not always bear out this assumption. Objections may be raised both against the older and some of the more recent material. In general, most of the recommendations are based on measurements of visual acuity; the technique has been essentially the same for the past 50 years.

If the technique of measurement as such affords no explanation for the increase of recommended illumination levels, it is possible that the interpretation of the same data has changed. Visibility measurements are threshold measurements, and there is a large margin of arbitrary judgment as to how much illumination should be added as a "safety factor" to the threshold values. It seems that the earlier investigators were satisfied with a comparatively narrow safety factor, while this safety factor has been tremendously increased in the recent recommendations. It is clear that the higher the "safety factor" (*i.e.* footcandles arbitrarily added to the threshold level), the more remote are the recommended levels from the experimental background of threshold measurements. The question arises, then, whether such an experimental basis is needed at all. One might be satisfied with general practical experience, and this has been, indeed, largely the case in arriving at the I.E.S. recommendations for various job categories. Staud[10] stated that the Illuminating Engineering Society was under pressure to give recommendations in several instances even in the absence of satisfactory experimental data, and thus "practice the art of illumination . . . in much the same way as physicians practice the art of healing."

TABLE I.

Work	Footcandles I.E.S.	Footcandles Weston (1949)
Sewing	50	30
Bookkeeping, calculating machines, typing	50	20
Drawing	50	30
School classrooms	30	15
Assembly—very small	over 100	100
Assembly—small	50 to 100	50
Inspection—very small	over 100	100
Inspection—small	50 to 100	50
Ordinary bench and machine work	20	10
Small bench and machine work	50 to 100	50
Matrixing	100	10
Lithographing, proof reading	over 100	20
Shoe stitching	30	20
Fine painting and finishing	50 to 100	30
Woodwork, fine sanding and finishing	50	20

It might be suggested that the increase in attainable illumination levels may have been the main reason for the increase of recommended illumination levels. It is technically easier and less expensive to provide today 20 footcandles on the working plane than 5 footcandles a few decades ago. Illumination codes are prepared for practical use; obviously, it makes little sense to recommend illumination levels which are practically not attainable. In this way, then, the illumination codes might be considered as a compromise between "ideal" conditions and practically attainable condition. It is stressed, in fact, in the latest illumination codes of the I.E.S., that the recommended levels are on the low side, and exceeding these values would be, if anything, beneficial. Luckiesh and Moss[11] have expressed the same view.

It is of considerable interest to compare the most recent British and American illumination codes. The Schedule of Recommended Values of Illumination, reprinted from the (British) I.E.S. Code for the Lighting of Building Interiors (1949), has been made generally available in Weston's book.[12] As an illustration, some of the listed work categories are shown in Table I, and compared with the corresponding values of the (American) I.E.S. codes for Industrial Lighting, 1942,[13] and for School

Lighting, 1948.[2] Throughout, the American recommendations are substantially higher.

The British material is based partly on Weston's performance studies with Landolt rings. A level of 90 per cent of the maximum performance level has been arbitrarily taken as index of sufficient illumination. In addition, results of plant investigations and existing practice were taken into account. It is not stated which of the recommendations are based on Weston's material, and which on other sources of information. As a whole, it seems that performance studies have been utilized to a greater extent than is the case in the American illumination codes.

The American codes are based on a different principle and a different material. As a goal, the recommendations should indicate the ideal illumination levels; however, the footcandle values of these ideal levels are not actually given. Actually, the American illumination codes give the upper limits of inadequate illumination. It is curious that these limits are substantially higher than the levels corresponding to 90 per cent of the attainable maximum performance in the British Code. While the time has not yet arrived for a final evaluation, the very fact of the discrepancies in the British and American I.E.S. Illumination Codes shows, if anything, the need for further research.

In recommending only "minimum" footcandle levels for a given job, the way is left open to any increase beyond that level with the advancement of illumination technique. In a recent conference on Light and Vision (Cleveland, April 24-25, 1950) the goal of as high illumination levels as technically possible was advised by Spencer,[14] who predicted future increase of footcandle levels much in the same way as has been the case in the past decades. If this philosophy is accepted, we would not need any illumination codes, including the "Delos" system recommended by Moon and Spencer.[15, 16]

There are obviously two ways open: to dispense with any pretense of a physiological basis for illumination codes and set the illumination level at a technically attainable intensity or to try to establish such a basis. There is no doubt in our mind that visual performance and fatigue should be approached as a physiological problem.

The complexity of the situation should not be overlooked. Visual work involves a variety of visual functions, and their critical involvement varies with the type of visual work. Furthermore, the visual fatigue is superimposed on fatigue resulting from stress placed on non-visual functions, since vision in occupational work is always associated with some other type of activity.

Approaches to the Study of Illumination and Visual Work

The main quantitative approaches consist in the study of performance, changes in visual functions and concomitant changes in non-visual physiological functions resulting from visual work, and in the prediction of visual stress from brief visual tests. We will not discuss practical illuminating experience as an approach to arrive at optimum conditions for visual work. Certainly, practical experience is important and should not be ignored; because of the absence of controlled observation, involving the use of experimental and statistical analysis, practical experience cannot be used for proper evaluation of visual variables. Also, it is subject to changes with the advances of illumination technique.

Brief Tests of Visual Functions

The effects of the level of illumination, surrounding brightness, and contrast were studied most intensively with reference to visual acuity (threshold size perception). This might explain why visual acuity was used as the main experimental basis for recommending footcandle levels. Contrast and illumination levels are interdependent variables, so that comparatively simple equations may be suggested to arrive at a reasonably adequate estimate of illumination requirements.[15, 16]

Recommending illumination levels for the various job categories amounts to a prediction that prolonged occupational work could be done under the suggested conditions of illumination with the greatest relative comfort and with a minimum degree of visual strain. The applicability of short term visibility measurements for such prediction has not been satisfactorily proven. On the contrary, there are data available indicating that it is not feasible to base on brief visibility measurements a prediction of ease of visual work extending over several hours.

There seems to be an agreement in recent publications that the use of short term visibility tests as basis for recommendations of illumination for prolonged work is questionable (Tinker,[18, 19] Bitterman,[20] Hoffman,[21] Ryan,[22] Simonson and Brozek[23]). As early as 1925, Freeman[9] found discrepancies between fatigue trends in visual functions during reading and the legibility. Tinker[17] observed no effect of increased illumination level on the speed of reading beyond a level of 25 footcandles, in contrast to the prediction from visibility measurements. While visual acuity tends to improve with increased illumination up to very high illumination levels, the improvement is very small after a bend in the curve had been reached at a comparatively

low level, so that any increase of illumination beyond that level is practically of no or little consequence (Tinker[18, 19]).

Another difficulty in the application of visibility measurements is the uncertainty of the amount of footcandles which have to be added to the threshold visibility values. Threshold vision is, of course, not suitable for prolonged or even for short periods of work, so that a substantially higher level of footcandles must be provided. However, we have no definite information as to *how much* the recommended levels should exceed the threshold values. Certainly, the ease of seeing or visual efficiency will not be indefinitely increased by increasing the illumination. After a certain level, further increase of the illumination will not produce any further increase of the ease of visual work. This is also one of the objections which have been made against the use of the Luckiesh-Moss visibility meter as a basis for illumination standards.[19, 20]

The Luckiesh-Moss visibilometer[11] reduces the visibility of any given object to threshold conditions by decreasing the contrast between the object and surrounding through an interposed filter of increasing density. This is an ingenious procedure to arrive at threshold values of visibility without varying the threshold size. The same procedure can be used for all types of visual work. The readings obtained with the visibilometer are not actually a measurement of visual acuity, since the size of the object is not changed. However, contrast and threshold size are interdependent variables so that, in a way, results obtained with the visibilometer are predictable from illumination level, object size, and contrast. The visibilometer gives, on a relative scale, the amount of density necessary to reduce an object to conditions of threshold visibility; consequently, this value will increase with size and contrast of the object for any level of illumination. If, however, there is no physiological differentiation in the ease of seeing when a certain combination of these variables is exceeded, the use of the visibilometer in tasks above the threshold would introduce an artificial differentiation, in contrast to the true situation.

The most serious objection against the use of visibility data as a basis for illumination standards is the arbitrary selection of a single visual function, tested under conditions quite dissimilar to actual working condition. Visual work involves a large number of visual functions which may respond differently to a given situation of visual stress. In our work task,[24] involving discrimination of small, moving objects, it was found that the trend for the recognition time for threshold size (visual acuity) with illumination level was different from all other visual functions tested. Thus different recommendations would have been made from the recognition time and from other visual functions.

Visibility tests are being made on stationary objects, with unlimited exposure time. Strenuous visual work, as a rule, involves several variables which add to the severity of the task. A recent paper by Tinker[25] shows that the combination of two marginal conditions (type of printing, level of illumination) produces a cumulative effect on the speed of reading. In our work task, several marginal conditions determined the severity of the task: the small size of the letters, the movement of the letters, and the short exposure time for each letter. It is curious that this was overlooked in the criticism of our results by competent authors (Luckiesh,[26] Staud[10]); they compared our data, obtained for moving objects with short exposure time, with recommendations based on data obtained with stationary objects and long exposure time.

The importance of movement perception for different work categories has been stressed by Weston.[12] Many industrial and clerical jobs involve also, to a significant degree, stereopsis and color perception (Weston,[12] Tiffin,[27] and Kuhn[28]), for which again visibility measurements do not provide any information.

Weston in his studies on illumination used extensively tests involving recognition of Landolt rings. This procedure is superior to visibility tests, since it involves work performance. However, the test performance is so short that application to prolonged performance remains questionable. This can be illustrated by a comparison of the initial performance, and the performance drop in our work task (Table II). The initial performance was measured during the first five minutes and is comparable in duration to Weston's tests. The drop is the difference between the scores obtained during the first and the last five minutes of two hours of work. The initial values show a pronounced improvement up to 15 footcandles, a slight improvement from 15 to 50 footcandles, and no change beyond that level. The performance decrement improves up to 100 footcandles and deteriorates at

TABLE II.

Initial performance and performance decrement at different levels of illumination. Scores in terms of number of correctly identified letters out of 300.

Footcandle level	Absolute score	
	Initial	Decrement
2	162.0	26.0
5	176.6	14.1
15	187.8	9.8
50	193.6	9.9
100	192.9	6.8
300	193.7	10.9

300 footcandles. The effect of the illumination level is different for short and prolonged performance. If this is the case for the same type of work, still greater discrepancies should be expected when standards for prolonged visual work are derived from such dissimilar test situations as visibility determinations.

In connection with this point, it may be of interest to quote from W. R. Miles' discussion at the Conference on Visual Fatigue, 1939:[1] ". . . there is always a difference between a short test and a long test. An individual forced with a fairly prolonged test as a rule gives a more reliable score result than can be gotten from a short test." The lack of reliability of short term tests is a general physiological phenomenon and by no means applicable only to visual work. As an example, we refer to studies on the effect of age on skilled manual performance in an experimental study carried out by Smith.[29] In a 15-minute work period, the average relative performance of the age groups 30, 40 and 50 was 100, 95.7 and 91.9 per cent, while in a four-hour period the relative performance was 100, 93.6 and 86.5 per cent. Short term tests would have been inaccurate basis for a prediction of sustained performance in the 50-year group.

Fatigue Trends in Visual Functions

Theoretically, deterioration of visual functions in the course of prolonged work is an important and objective criterion for visual fatigue. The procedure is comparatively simple; any given visual function may be tested before and after work, with little or no interference with the work performance proper. It should be noted that not all changes in visual functions are indicative of visual fatigue; actually some changes may indicate improvement. Analogous facts were observed in the study of muscular fatigue. Any type of muscular work will increase the oxygen consumption during work, but the increase of oxygen consumption alone does not indicate fatigue. Only when the level of the oxygen consumption (or the oxygen debt) increases with the prolongation of work, the interpretation of this change as a fatigue trend is justified. Similarly, changes of visual functions, tested before and after a work period, can be interpreted as fatigue changes only when there is a trend in the direction of deterioration. The total situation is complicated by adaptation trends which have been observed for various types of work and are probably a general physiological phenomenon (Simonson[30]). Adaptation trends are the reverse of fatigue trends and may be quite prolonged. In our work a period of two hours resulted in an adaptive change in the convergence power, but when the work task was prolonged to four hours a deterioration (fatigue) became apparent. The existence of adaptation trends was ignored by Carmichael and Dearborn[31] in the interpretation of their results (Brozek[32]).

The material on fatigue trends in visual functions measured during prolonged visual work (or tested before and after the work) is scanty and, in general, disappointing. One of the most thorough investigations yet performed is the study on reading by Carmichael and Dearborn;[31] surprisingly enough, the changes in visual functions, occurring during six hours of reading were slight. Luckiesh and Moss[11] earlier finding of definite fatigue trends in several visual functions in subjects reading 12-point Bodoni type for only one hour is hard to reconcile with Carmichael and Dearborn's results.

In our test-battery of 23 items[23] comparatively few showed significant fatigue trends. The eye muscle tests which are often used by ophthalmologists to detect fatigue in patients complaining about visual fatigue were among the more insensitive tests. One of the tests indicative of deterioration (fatigue) was the fusion frequency of flicker. The results have been recently confirmed by Ryan and Bitterman[14] in another, though less strenuous, type of visual work.

Bogoslovskij[33] studied visual work of sufficient severity to produce fatigue, but he used a very uncommon criterion of fatigue, an increase in the threshold for light sensation produced by electrical stimulation of the eye. Objections can be made against Ferree and Rand's[34] criterion—appearance of blurring on continuous fixation of a letter—as the significance or physiological basis of this test is obscure.

White et al[35] found a deterioration of the visual acuity in post office employees at the end of the working day. However, neither the AM-PM deterioration of visual acuity nor the AM values showed a consistent relationship to work illumination levels, varied from 2.4 to 10.7 footcandles in consecutive prolonged experiments. It is strange, therefore, that Luckiesh and Moss[11] drew the conclusion that "This investigation provides rather direct evidence that higher footcandle-levels may permanently benefit the visual organs themselves when the latter have been impaired by long service under unfavorable conditions for seeing." (pp. 257-258). Two years later, at the Conference on Visual Fatigue 1939,[1] F. K. Moss said "We have also conducted numerous experiments using the decrement in some visual function, such as acuity or contrast-sensitivity, as an indicator of visual fatigue. In general, these experimental approaches seldom yield important differences in visual function even after prolonged seeing under favorable and un-

favorable conditions, respectively." Yet, the interpretation of White's et al[25] results was not changed in the 1943 edition of *Science of Seeing*. In our experimental series, visual acuity did not change during the work, but there was a deterioration trend in the recognition time for threshold size. However, the variability of this function was quite large.

Although the results of studies on fatigue of single visual functions have been, in general, disappointing, we should not be discouraged from continuing the research. Taken all in all, only the more conventional methods have been tried. It is quite possible that ultimate progress will be made by the application of newer techniques. Numerous approaches are still open.

Fatigue Trends in Non-Visual Functions

Luckiesh and Moss[11] made the very important point that visual fatigue is not an isolated process; vision involves the body as a whole. Therefore, concomitant changes in non-visual functions could be expected to develop during prolonged visual work and such involvement might serve as a fatigue index as important as the changes in strictly visual functions. Luckiesh and Moss' approach is basically correct, but their results have been challenged, and at present the matter is still in a controversial state. We do not intend to discuss critically the details of this controversy. However, one observation made by Bitterman et al[36, 36a] is of more specific interest. He found that in work performed at speed dependent only on the subject, muscle tension did not change significantly. In contrast, there was a significant increase of muscle tension when the work was performed at a predetermined rate, to which the subjects had to adjust.

In a recent study by the same authors[37] measurements of the muscle tension failed to differentiate between 5 and 50 footcandles, and to not confirm Luckiesh and Moss' earlier work on muscle tension.[11] However, the difference in the method should be noted: Luckiesh and Moss measured mechanical tension, while Bitterman and Ryan measured the electrical activity. The correlation between mechanical and electrical activity is far from complete.

Luckiesh and Moss'[38] work on the change of the heart rate suffers from a misinterpretation of adaptation (improvement) trends as fatigue trends. The lower heart rate at poorer illumination contradicts, in fact, Luckiesh and Moss' whole philosophy. Most investigators[39, 40] failed to confirm their findings.

In regard to the controversy about the blinking rate, our own results[23] are of interest. Although the *average* blinking rate showed a significant differentiation of illumination levels, in agreement with Luckiesh and Moss' findings, the *changes* of the blinking rate during work were not consistent and could not be used as a fatigue index. In fact, the rate actually decreased ("improved") under extreme conditions of stress (at 2 ft-c). Probably, this trend of the blinking rate was a compensatory phenomenon.[41]

In a recent study on the changes of the blink rate during reading for 55 minutes at 2 and 100 footcandles, Tinker[42] found a significant trend towards deterioration during the performance, but no significant differentiation between illumination levels. These results seem to be contradictory to ours, but an explanation for the discrepancies can be given. The mean changes of the blinking rate during the performance were in the direction towards deterioration (increase in the rate) also in the majority of our experiments. The magnitude of the mean changes were of about the same order as those in Tinker's experiment, but were statistically not significant. However, the standard deviations were high also in Tinker's series, so that the statistical significance in Tinker's results is due to the larger number of subjects.[42]

It seems to be a somewhat circuitous route to use remote and non-specific effects of visual work as indices for visual fatigue, before the specific effects of visual work on visual functions were thoroughly explored. However, the failure to detect fatigue trends in specific visual functions was probably one of the reasons to venture in this direction. Still, this approach is of definite interest, since more general effects would indicate a more general involvement. Most of the experience accumulated during the recent years seems to indicate that the situation is very complex and no simple correlation between remote functions and visual variables can be expected.

Industrial Work Performance

The most important practical criterion for a comparison of variables of illumination is undoubtedly the work performance. At the same time, it is open to interference from numerous sources of external and internal factors, and, of all visual tests, hardest to standardize and evaluate quantitatively. Since in most of the studies necessary precautions were ignored, work performance as a measure of visual fatigue has been discredited to a large extent. However, when all interference factors are eliminated as far as possible, visual work performance is the most revealing and significant index for visual fatigue and a comparison of illumination variables.[23]

Actual performance in industry may be regarded as a product of "capacity" and "motivation" (Brozek and Monke[43]). Obviously, motivation is a highly variable factor, dependent on social pressures rather than on physiological limits. In plant investigations, the social factors may determine the daily performance to a greater extent than the physiological limitations, as shown in the Hawthorne studies.[44, 45] For this reason, investigations in plants rarely offer the opportunity for obtaining reliable data on changes of work capacity as an index of visual stress or fatigue.

As a rule, in plant investigations an initial low level of illumination has been compared with a following period of a higher level of illumination, followed again (though not in all experiments) by a control period of lower illumination. While in most experiments the output increased at the higher level of illumination, it often failed to decrease in the following control period with lower illumination. This result is obviously due to prolonged practice trends or a change in motivation, for instance in the studies by Ives[47] and White et al[35] on letter sorting in a post-office and in switch assembly work (Snow[46]). Even in types of miniature job situations, such as placing metal rods or lettered cards into different fields, or putting pearls on a wire, similar observations were made (Ruffer[48]), probably due to prolonged training trends for manual skill involved in the work performance. Luckiesh and Moss[11] observed an increase of production in key-punching after an increase of the illumination level. After six months, a plateau was reached and maintained for eight months, followed by a further increase of performance of about the same magnitude as that observed after improvement of the illumination, but not explained by any further change of the illumination level. After four months of the second increase, the illumination reached another plateau, which was maintained for 10 months, *i.e.* until the end of the observations.

In general, in industrial investigations the workers were aware of the change of illumination, so that suggestion may have played an important role. Simply changing bulbs of the same voltage has produced an increase of the output.[46] In other types of work, for instance, inspection of switch jack shells and springs, the variations of the output showed no relation to variations of the illumination level (Snow[46]). The extensive work sponsored by the National Research Council in the early twenties demonstrated the presence of so numerous interference factors that it was difficult to isolate the benefits of good illumination.

It is of interest that in poorly controlled plant investigations the effect of a decrease of illumination is far less uniform than the effect of an increase of illumination. As an example, the Hawthorne experiments[44, 45] may be mentioned. After the results of two experimental series were discarded because of inadequate control of experimental conditions, a third series was undertaken. The initial level was 10 footcandles and was reduced by one footcandle per period to a level of three footcandles. Despite discomfort at this low level of illumination, the output (winding coils) remained unchanged. In a fourth experiment on two workers, the intensity was lowered to the level of "ordinary moonlight," but the production remained the same and "no eyestrain and less fatigue than when working under bright light" was reported. Obviously, the involvement of visual components must have been trivial, and yet, results of such experiments are commonly accepted without criticism in the visual literature. Clearly, in such types of plant investigations no definite conclusion as to the effect of the illumination level can be made. The same criticism applies also to much of the work done under the auspices of the I.E.S. For instance in the report on Lighting in the Shoe Industry,[49] it is stated that productivity increased four per cent. One asks, naturally, in what tasks this increase was observed, what control observations have been made, how large were the daily fluctuations of productivity and how do they compare with the observed improvement of four per cent, how large was the sample, whether practice or motivation trends were taken into account, etc.; no such information was given. In the report on the Printing Industry[50] it was stated that 200 printers were asked to proof-read sheets containing six errors. The number of letters per sheet was not stated, but since it was said that five minutes were ample for the test job, the number of sheets must have been very small; obviously this test involved no fatigue. At an illumination level of 50 footcandles, 35 per cent more errors were discovered than at a level of 8 ft-c. The use of percentages in this way is a hazardous procedure; two errors per sheet would correspond to such difference. The statistical significance of the difference was not determined. The proper conclusions to be drawn from this study are clearly very limited.

Weston has summarized the results of investigations on weavers, sponsored by the British Industrial Fatigue Research Board. Throughout the year, there was a parallelism between output and daylight illumination which determined also the work-place illumination. It is of interest that additional artificial illumination did not change the trend of the curves, but it is stated that the arti-

ficial illumination was rather poor. The difference of output in summer and winter is impressive, but obviously many other factors enter the picture, so that it is questionable whether the difference in the output is due only to the difference in the illumination level.

In the evaluation of performance quantity as well as quality should should be considered. Both are interrelated and may follow different trends, i.e. the quantity may be increased at the expense of quality. This has been shown in general by Sachsenberg,[51] and more specifically in regard to visual work by Tiffin[27] and by Ströer.[52] It is advisable, therefore, to eliminate one or the other factor in the experimental task. In reading tasks, for instance, only the speed (quantity) is left as a functional variable, while in conveyor type work (like in our work task) the rate of work is given and only the quality (errors, or number of correctly identified details) is evaluated. The encouraging results obtained with the latter procedures have been confirmed by Bitterman;[26, 26a] he found consistent fatigue trends of muscle tension under various conditions of illumination only when the speed of work was determined and not when the reading was done at a voluntary speed. Of interest for the evaluation of performance is Ströer's observation confirmed by other authors,[53] that the variability of performance can be used at times as a fatigue index.

Laboratory Studies on Work Performance

Reading, perhaps, has been used to a greater extent than all other types of laboratory performance for evaluation of visual variables. Speed of reading, provided that motivation and intellectual components are kept constant, is a sensitive criterion of the ease of seeing and consistent results have been obtained in the hand of experienced observers (Tinker[19]). It should be kept in mind, however, that reading of 10 or 12 point letters for one hour or so, even at fairly low illumination, is not a very hard visual task. Reading as such is of tremendous importance, since it comprises the essential visual work in a large number of clerical workers, but results from reading should not be generalized to different types of visual work.

The work tasks used in laboratory investigations on illumination and work performance should meet the following requirements: (1) easy standardization of work performance, (2) possibility of quantitative evaluation, (3) clear cut relationship to fundamental visual functions, (4) elimination of auxiliary functions such as manual skill or verbal intelligence which might influence the results significantly, (5) negligible effects of practice, (6) practical applicability of results, and (7) possibility of varying critical factors of performance. Such work task can be classified as "miniature job situation," reproducing essential features of industrial work in the controlled conditions of the laboratory. This seems to be the ideal approach for the study of visual performance and visual variables.

In a miniature work situation, where most of the interference factors can be eliminated or standardized, performance is a more sensitive index for differentiation between variables of illumination and for the discovery of visual fatigue than concomitant changes in visual or non-visual functions. This was true for our work task, measurement of the width of metal pegs by means of a caliper, and some of Goldstern and Putnoky's work.[54] In general, the work output increased up to a moderate level where it reached a plateau or declined when that level was exceeded. Observations of an optimum in our work task confirm similar findings made by Ströer, Ferree and Rand, and Weston.

The demonstration of an optimum has the most immediate bearing on the question of footcandle recommendations. It is implied in the illumination codes of the I.E.S., in fact directly stated,[13] "that the values given are *minimum* operating values . . . and in almost every instance higher values may be used with greater benefit." The existence of an optimum illumination level is not compatible with such an approach.

The position of the optimum illumination level will certainly depend on the type of work; in our work task, it appeared at the level of about 100 footcandles. We do not attach any magic meaning to the 100 ft-c level. In fact, even in our case the optimum is not necessarily identical with 100 ft-c. We can say with certainty that it lies between 50 and 300 ft-c. Here we are concerned with the fact that there *is* an optimum, not with the particular optimal footcandle level.

The values given in ideal illumination codes should coincide with the optimum illumination level. In our case, the optimum illumination level of 100 ft-c was below the level which, in logical interpretation of the illumination code,[13] would have been recommended for our work task. Such interpretation is somewhat arbitrary, since our work task does not exist in nature, but it is definitely harder than most of the jobs for which a level of 100 ft-c or higher is suggested. It may be objected that in most instances the illumination levels found in surveys are far below the recommended "minimum" levels, so that there is little likelihood that the optimum level will be attained or exceeded in industrial practice. This may be so, but it does not make a wrong principle sound.

Integrative Studies

In the preceding sections the various experimental approaches to the study of illumination and visual performance were discussed, one at a time. Such a subdivision is necessary for presentation and discussion, but it ignores the fact that all the approaches should be combined in order to arrive at a full picture. Such type of research was suggested at the Conference on Visual Fatigue, Washington 1939, as mentioned in the introduction. Controlled observations on performance should be combined with the measurement of fatigue trends in visual and non-visual functions before and after the work, on as large a scale as possible. Only few such studies have been made (Ströer,[52] Bitterman and Ryan,[36a] Carmichael and Dearborn.[31]). We have attempted to approach the ideal of integrating studies of performance, single visual functions, and the subjective reactions of the subjects in a series of experiments carried out at this laboratory.[23, 55, 56, 57] The fact that only a comparatively small number of the items tested showed fatigue changes should not discourage further research, nor does it prove that the approach is wrong. It is only through the accumulated work of many investigators that we may hope finally to arrive at a satisfactory test-battery and at more accurate recommendations of the quality and intensity of illumination.

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DISCUSSION

C. L. CROUCH*: When I was a boy on the farm I operated the bellows on the forge and watched my father weld two pieces of iron together. When the metal was white hot the two were forged together in the anvil with many hammer blows until the piece was not only welded together but was stronger than ever before. In this paper we have invited Drs. Simonson and Brozek to rain a series of hammer blows on our structure of footcandle recommendations; from such a process we hope to forge a stronger base than ever before for our illumination standards.

As I have stated before, viewpoints in the illumination field are so often like those of the blind men of Hindustan: one declares it "verily like a wall," another "like a tree," another "like a rope," etc. To each a particular feature looms so large it overwhelms the sense of the other characteristics. But each is right. Each has comprehended a segment of the truth. The authors have conducted noteworthy tests from which we may learn some fine truths, but we question whether they can wisely extrapolate their results to challenge all other conclusions. Let us examine some of their points.

There is a reiteration of the oft repeated inference of the instability of footcandle recommendations by comparing the present recommendations with those of the past. To our generation which has little difficulty in producing levels of illumination of 50 to 100 or more footcandles, it may seem puzzling to review the statements of early lighting leaders who declared that 2 to 3 footcandles provided comfortable illumination. In their day it was an engineering feat to nurse a few lumens from a feeble source and cajole them into arriving at the working surface. Because eyes are so remarkably adaptable, it was possible for the lighting designers to pronounce with a degree of pride of accomplishment that several footcandles produced a comfortable and satisfactory installation.

If one will closely examine the literature, however, he will find that daylighting has ever formed a base of reference to which instinctively all efforts have been oriented. The old masters have portrayed their subjects seeking the light of day for the work at hand. For ages architecture has been designed to take advantage of Nature's bounty. Until only recently artificial lighting has been thought of as feebly supplementing the failing daylight. As long as Nature's light contributes a basic urge, people will ever strive to bring its benefits indoors as part of the working environment. Conclusions, derived from a limited test, proposing to limit footcandles to low levels are denying that basic urge. Now, with the ready availability of a variety of efficient light sources and controlling media, we are able to think of designing our working environment with a feeling, to a degree, of bringing Nature indoors.

The authors have further used the familiar pattern of contrasting our recommended levels with those of other countries. The principle is fundamentally the same as comparison with previous years. It is all a matter of the degree to which the other nations can economically approach the universal goal as described above. If one will examine the literature of Great Britain which the authors have used for an example, one will find that they have set their levels in accordance with their judgment of the economic status that they currently have. There are statements which indicate a gentle yearning toward those levels which are currently used in America.

The authors indicate that the American codes seem predicated upon ideal illumination levels (which are not stated) and that the actual recommendations termed "minimum" appear to give "upper limits of inadequate illumination." Since 1946 the Society has had a policy of terming all footcandle recommendations as "Current Recommended Practice." Before that the term "minimum" was used for a number of years, and before that a range of values was given.

In the early days when a range of illumination levels was recommended it was found that economic pressures resulted in a selection of the minimum values in the range, with too often a disappointing result. Too many times the practicing engineer has learned that a "halfway" job soon results in disappointment from both the designer's viewpoint and especially from the client's reaction. It appears to be the way of all flesh to let the mediocre job rapidly deteriorate into its former deadening environment. Therefore, the Society decided to set up recommendations on the basis of minimum values for a satisfactory job in the current economic situation. Later, with improved economic conditions of new and far more efficient light sources and decreased costs of energy and equipment it was deemed best to merely present "current good practice." However, there has been one exception to this in the School Lighting Practice where non I.E.S. members in an American Standards Association Sectional Committee instituted relabeling the footcandle recommendations as "minimum," apparently feeling that 30 footcandles for the classroom represented "minimum good practice."

Since the authors question whether there is any rational basis for the I.E.S. recommendations, it seems appropriate to review for them the evidence on the current basis of analysis that has been used by the Society.

Briefly summarizing what has been set forth previously in detail,[1] the engineer and psychophysicist in illumination divide the visual factors of the task into four major variables — size, contrast, time and brightness. Visual capacity (sometimes termed "efficiency"), age, accuracy and color are presented in literature as other modifying factors having important influence on seeing. It is found by combining the experimental points from a number of studies of visual acuity that the median curve is an S-curve[2] with the ability of the eyes to see fineness of detail increasing up to Nature's footcandle levels (several thousand footcandles). Repeating

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Figure 1. The finished cloth is inspected on perch boards. Supplementary lighting units containing ten 40-watt daylight fluorescent lamps in specular reflectors provide the 300 to 400 footcandles required for this seeing task. Wrong colors of thread, off-shades, spots, shadiness of goods and mistakes in patterns must be seen with very poor contrast in most cases, and especially with dark cloth.

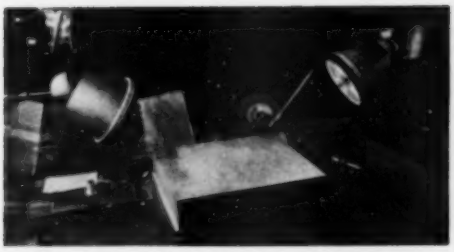

Figure 2. Supplementary lighting delivering over 200 footcandles necessary to see fine scribed lines against metal background. Lines seen because of slight shadow or highlight. Lighting as illustrated was demanded by die-layout man.

Figure 2b. Close-up of detail.

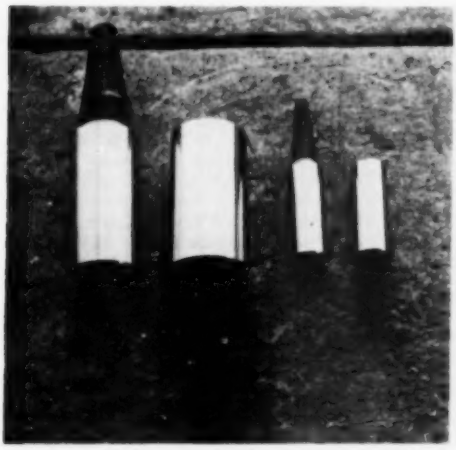

Figure 3. Polished gages as seen under daylight illumination at window benches. Extremely fine scratches must be seen as interruptions of highlights.

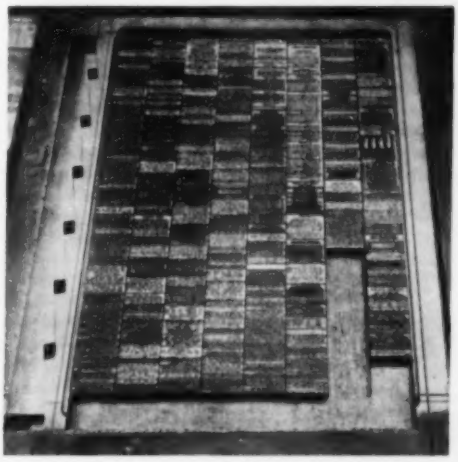

Figure 4. Working on type involving fine detail and poor contrast requires high levels of illumination (100 footcandles or more) with controlled brightness.

the same analysis with *contrast* it is found that the same general results hold, although differing in degree. From the work of Ferree and Rand and Cobb we find the ability to see size and contrast increasing as related to *time* up to 100 footcandles and the curves still rising sharply.[1] Thus, the general indices of visual performance as related to the four fundamental factors show benefits to be obtained up to Nature's levels of illumination. The above laboratory results in general apply to young normal or normally corrected vision observers and a laboratory accuracy of a little over 50 per cent correct answers. Age and accuracy factors each demand two to four times the illumination for similar results.

While the general ability of the eye to see the four fundamental factors increases with illumination there is still something to be desired regarding a particular task with a given size, contrast and time of seeing. Here is where a variety of approaches are encountered and the ideas of "the wise men of Hindustan" cause a babel of confusion. In general, the ideas can be separated into two concepts — performance with illumination, and cost of seeing with illumination. Up to the present time it appears that the performance ap-

proach is easier to evaluate than trying to measure the effort of seeing a given task under various levels of illumination. It is postulated by some that after maximum performance has been reached further increases of illumination will result in decreased effort. Studies on cost of seeing are being carried out along several lines at the present time. The authors use the performance method in a unique way to evaluate the cost of seeing through measurement of the decrement of work output over a suitable work period.

Obviously, in the performance approach it would be ideal to run the laboratory tests on the actual work task encountered in commerce, industry or public service. It is equally obvious that this is impossible due to the almost infinite variety of tasks encountered, each having a particular size, contrast, and time of viewing. Therefore, the researchers have resorted to the selection of a particular hypothetical task which they regard as roughly representative of field tasks. Differences of opinion arise over the nature of the test object and its application to field practice and over the method of testing performance. Many researchers like the studies of Weston, conducted at the British National Physical Laboratory under the auspices of the Medical Research Council, using Landolt rings. The British program[3, 4, 5, 6] resulting in Weston's work was based on the concept that studies could establish the illumination required for various sizes of test objects and then find the multiplying factors for contrast, motion, age, etc. It is true that young normal or normally corrected vision observers were used in the basic tests and care was taken to have them fresh. If Weston had carried on his test for two hours as Simonson and Brozek did, one would expect that he would have obtained another multiplying factor for fatigue since the authors found an appreciable gain in benefits of increased illumination over such a work period.

Tinker[7] conducted performance tests on reading. For printed material he found the maximum reading performance occurring at less than 10 footcandles. He used nonsense words in the test to determine if the subject was understanding the printed material. However, he did not attempt to subtract the mechanical and mental components of performance. It, therefore, appears that aside from the visual performance there were the complexities of sizable mechanical and mental operations which would largely conceal the net visual gain due to increased illumination. When Weston segregated and subtracted these components he found that illumination had a far greater role than Tinker's results show. This would seem to be a very important consideration in all performance tests in order to isolate the true function of visual response.

The authors have conducted a noteworthy study of performance. It was their desire to really "test the mettle" of visual performance by designing a difficult enough task to show differences in performance due to illumination level. They used 3½ point capital letters spaced irregularly on a moving belt so that they would appear momentarily in a slot 4 inches in height—presenting a challenge of difficulty to the observer to identify such tiny detail in the instant of exposure. While the overall letter presented an object approximately 10 minutes in visual size, the stroke of the letter was probably in the order of 2 minutes in size. Thus the critical detail (stroke width) would correspond roughly to Weston's second size of Landolt *C* with probably the same degree of contrast of black on white, and also to the 20/40 line on the Snellen or A.M.A. eye test charts. It is comparable to Ferree and Rand's 2 minute size Landolt ring (black 3·4 per cent reflectance vs 78 per cent white background) on which speed of identification tests were run by means of a tachistoscopic presentation. Since both Weston's and Ferree and Rand's work involve some similar characteristics it is interesting to compare their results with those of Simonson and Brozek. Weston's tests involved movement of the eyes and momentary fixation. Simonson and Brozek's involved movement of the eyes up and down a 4 inch slot and momentary fixation. Ferree and Rand's involved looking toward a fixation point and momentary exposure of the "C." Weston subtracted the mechanical time of scanning; Simonson and Brozek did not; Ferree and Rand reduced it to a negligible factor.

The results are interestingly comparative. Weston's performance was still rising up to 500 footcandles in a very carefully controlled illumination booth.[4] Ferree and Rand's performance was rising sharply at 100 footcandles, the limit to which the tests were run. Simonson and Brozek reached a plateau of performance extending between 100 and 300 footcandles under initial conditions. Simonson and Brozek carried on the work for a 2 hour period to get fatigue reaction which the others did not. (They are to be commended for this extension of study to encompass such practical fatigue aspect. Their discussion on the short versus long term test is indeed helpful. Their "decrement of performance" is an interesting and promising concept.)

The question arises as to why the illumination effects were different from those of the other investigators. Two possibilities appear: (1) that they did not subtract mechanical time to get the net visual response, and (2) that the visual environment was not conducive to optimum performance at higher levels. From our previous discussion of the first point and Weston's results, I recommend this point for the serious consideration of the authors. To the second point I am inclined to attach some importance; the authors' setup presents the possibility of a slight but significant factor of glare which would influence the results at the higher levels of illumination. Experience with high intensity local sources indicates that if the surroundings are not very carefully controlled the high brightness area in the neighborhood of the task can build up a cumulative sense of too much brightness. This may not appear to be so at first when the observer is fresh but it seems definitely cumulative. While the observer was not to take his eyes from the area of the slot and the light housing of the belt, there were dark desk areas immediately below his gaze which would present a strong sense of high brightness difference. Cobb found, upon varying the extent of the light surroundings of the task, that the degree of accuracy of setting moving pointers opposite each other was influenced by increasing the angular subtense of the surrounds to 60 degrees. If the axis of vision varied up and down a 4-inch slot, the 60-degree field factor would include nearly 80 degrees vertically. With 300 footcandles on the slot the brightness of the task and immediate surroundings would be about 240 footlamberts. The table with a reflectance of about 10 per cent and footcandles of not more than 25 would probably have a brightness of one one-hundredth that of the task. According to Lythgoe, Cobb and the 1919 I.E.S. Glare Committee (Nutting, etc.) there is a decrement of visual acuity and contrast sensitivity; the Committee considered such a brightness ratio of 100 to 1 as the threshold of glare (for low levels of illumination). Recent studies by Holladay,[8] Guth,[9, 10, 11] and Petherbridge and Hopkinson[12] indicate

lower and lower ratios for threshold of discomfort glare with increasing levels of field brightness.

Therefore, with this glare condition and no correction for mechanical components it was natural that there should be both a plateau of performance initially, and particularly from the cumulative glare condition, a decrement of performance over the two-hour period.*

The authors conclude particularly from the decrement of performance beyond 100 footcandles that there is an optimum illumination for various tasks. This does not appear to be warranted except under conditions of glare. Lythgoe[12] points out that König's curve of visual acuity only shows a decrement because of glare due to dark surroundings. There are numerous instances in the literature where daylight (without glare) of several hundred footcandles was used and considered optimum. The authors refer to Weston's summary of investigations on weavers where it was found that daylight illumination caused an impressive output of work. Weston in his recent text[14] describes the lace makers of Bruges taking their work out in the daylight. Lythgoe[15] describes the lace makers of Geneva taking their work outside as an illustration of greater visual ability (comparable to the visual acuity curve) under high levels of illumination. Nickerson[16] describes good color matching conditions under actual installations having 100 to 400 footcandles. For years hospital operations have been carried out under daylighting fenestration giving hundreds of footcandles. I am inclined to think Simonson and Brozek would agree that with proper seeing conditions the curves of performance should take the form of the visual S curves for psychophysical functions and, therefore, become asymptotic to a maximum with no declination. Their results, however, do point up the need for a comprehensive knowledge of optimum seeing conditions so that in field practice there are no environmental conditions militating against optimum performance.

In conclusion, therefore, I agree with the authors that they have conducted an interesting and helpful test. I cannot agree that it can be extrapolated to represent all difficult tasks, because while it represents the lower order of size, it has maximum contrast of black on white and is a comparative to Weston's and Ferree and Rand's 2-minute size test object with maximum contrast. Both of these other investigations showed that not only greater footcandles were necessary for equivalent tasks but that poorer contrasts found so largely in industry required far more illumination (up to 10 times more), and both used momentary exposure or equivalence thereof. While the authors purport to show a maximum it appears to be a false maximum induced by glare. Such a "maximum" concept does not jibe with psychophysical phenomena or with performance found in many practical daylighting situations. Their inference in other papers[17, 18] that their test is representative of the most difficult seeing tasks and, since a maximum occurred at 100 footcandles, that no more illumination is ever necessary is unwarranted and misleading.

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SYLVESTER K. GUTH*: In reviewing a fairly representative segment of the voluminous literature pertaining to this subject Drs. Simonson and Brozek have ably expressed the viewpoint of the physiologist. It is important to all of us to have such an analysis brought before us to help us take stock of our present position and of our unsolved problems.

The authors seem to imply that progress in an art should await complete scientific determination of all factors involved. Yet we all know that experience often proves a highly useful guide and makes sound progress possible while awaiting the results of definitive investigations.

The I.E.S. recommended standards of practice have never been intended nor represented as the ideal levels of illumination for various job categories. Their purpose has been to recommend what the experience of users has indicated as reasonable and attainable footcandle levels consistent with the benefits obtained and the cost involved. It is not surprising that footcandle recommendations have increased and probably will continue to increase when it is considered how on one hand the cost of lighting has decreased and, on the other, how the cost of the things light influences has gone up.

The question of statistical significance is raised. It is emphasized that there can be a great difference between practical significance and statistical significance. For example, an increase of one per cent in productivity or quality of performance may be very significant on the profit and loss statement of a manufacturer. The actual cost of an improved lighting system may be such a relatively small percentage of the total operating costs of a factory or office that a very modest increase in productivity more than compensates. In addition, there are other valuable plus

*This conclusion appears to be further confirmed by the recognition of dot tests immediately after the two-hour work period where, without glare and mechanical scanning, it was found that 300 footcandles produced a greater performance than 100 footcandles.

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factors such as improved worker morale, lower labor turnover, etc. All of these are given consideration in the development of recommended lighting practice.

Several of the criteria which have been investigated in studying the effects of light and lighting upon human beings have been criticized by the authors. Unfortunately, there seems to be no single criterion which enables us to appraise the overall efficiency of a worker at a given time and as affected for the long run. Therefore, it is desirable to try to make use of as many approaches as possible in order to help establish in what directions the results point—whether they tend to be conflicting or confirming. Even threshold measurements such as visual acuity and contrast sensitivity are important stepping stones towards the evaluation of relative illumination requirements. Speed and accuracy of performance data contribute much even though they may not tell us a great deal about the effort involved in performing a specific task. The rate of blinking, nervous muscular tension and other criteria have been studied for possible indications of ease of seeing or human effort. Even though there may be limitations in the application and interpretation of a criterion, it may provide supplementary information which related with experience will assist in developing recommended practice. A criterion or method of approach should not be thrown out because of the results obtained in any single situation. It is highly significant that countless experiments by many investigators point to improved seeing conditions as levels of illumination — or more accurately, the brightness levels of tasks — are increased even beyond those generally in use today.

A major problem is to translate laboratory data into practical terms. Few of the criteria can be applied to actual field tests. Therefore, it becomes necessary to try to develop means of evaluating all types of visual tasks on a rational basis. One such method involves the Luckiesh-Moss Visibility Meter which was designed to appraise the relative suprathreshold visibility of tasks and to indicate the illumination necessary to make these tasks equally visible. The visibility meter was never intended to be used as the sole basis for establishing recommended footcandle levels but as an instrumental aid in getting the dimensions of one factor in the problem. Visibility, performance and ease of seeing are not necessarily synonymous; different criteria must be used to appraise each. As Simonson and Brozek have pointed out, additional research is needed by many investigators to unravel the numerous complexities of light, vision and seeing.

ERNEST SIMONSON and JOSEF BROZEK*: We wish to emphasize at the outset that we completely share Mr. Crouch's view that mutual, constructive criticism is the best way to forge a strong basis for further progress. We have offered our criticism in this spirit and are glad to consider — *sine ira, cum studio* — his criticism of our point of view.

Our paper, as presented at the meeting, was primarily concerned with the general matters of approach and interpretation, and our own results were used only as a modest contribution to the general fund of information. Since Mr. Crouch's criticism is mainly levelled at the validity of our experimental set-up and conclusions, we may be permitted to outline very briefly the background of our studies on illumination.

For a decade we have been studying, at the Laboratory of Physiological Hygiene, University of Minnesota, the adaptation of man to his environment, under ordinary conditions as well as under conditions of environmental stress. Since illumination is one of the fundamental environmental variables, it could not be ignored in the larger aspect of our work. Therefore, our results should be understood in the general context of our primary interests: the relationship between man, especially the working man, and his environment. We are not wedded to any specific recommendation of illumination, whether high or low, nor to any particular arrangement of illumination. Our main concern is to provide a scientific basis for improving human efficiency in respect to illumination as well as to other environmental variables. Naturally, we approached the problem and interpreted the data not only on the basis of the specific information on vision and illumination but also on the general established laws governing physiological responses to a variety of environmental stresses.

Approaching the same problem from different angles naturally leads to conflicting opinions, interpretations, and conclusions.

Mr. Crouch and we seem to be at variance as to which set of findings is relevant and which is of little import to practical matters of seeing. Basing his argument on the visibility measurements (visual acuity, contrast, etc.), which show unquestionably a continuous "improvement" with increased illumination, Mr. Crouch suggests that the finding of an optimum illumination level is an exception which should be explained as some kind of artefact. We are starting from the physiological basis of human performance and come to exactly the opposite conclusions: that the optimum is the rule, and that it is the trend of the visibility data which needs to be "explained away." There is overwhelming experimental evidence that mechanical efficiency in any type of muscular work shows an optimum with the change of any fundamental variable such as speed, load, or extent of movement. Furthermore, the other environmental components such as temperature, humidity, barometric pressure, have a physiological optimum. There is no reason why visual performance should behave differently. In fact, most of the investigators who studied visual performance, including Weston to whom Mr. Crouch refers specifically, found an optimum, and so did we. The optimum, therefore, is a characteristic of *performance*, but not necessarily of threshold measurements. Our prediction is that with lesser contrast there will be also an optimum, although it might be considerably higher than 100 ft-c.

We are convinced that visibility measurements, and other threshold measurements, are not relevant or representative for the evaluation of conditions of visual work which is, as a rule, carried out well above threshold conditions. Therefore, they are not an adequate basis for recommendation of illumination levels. We wish to refer to our other points of criticism made in the text of our paper.

Mr. Crouch makes the interesting suggestion that the "scanning time" or the presence of glare might explain our results. The first suggestion can be discussed very briefly, but the second one merits a more thorough consideration.

In all inspection operations, "scanning" is an essential component of performance. A "correction" for the scanning time does not seem to be justified. In fact, "scanning" represented 100 per cent of the working time in our test.

With reference to glare, great care was taken to eliminate any "glaring" spots in our arrangement. Mr. Crouch suggests that some sub-threshold glare might have been present, and this is quite possible. However, our arrangement was far more ideal than most, if not all, actual work situations ever will be. Therefore, if sub-threshold glare was present

*Authors.

at our high illumination level, it will be also present at similar illumination levels in industry, and in all likelihood it will be much more pronounced.

Actually, it does not seem to make much difference whether the untoward effects of high illumination are called sub threshold glare or not since some degree of "glare"—sub threshold or manifest — is an attribute of high illumination levels.

This brings the discussion to one of the first points made by Mr. Crouch: the effect of the advancement of illumination technique on the recommendations. Actually, Mr. Crouch bears out to perfection our suggestion that technical progress is mainly responsible for the increase of *recommended* illumination levels. If the recommendations have only a technological basis, there would actually be no reason for physiologists to participate in the discussion at all.

The limitations of a purely "technological" approach could be pointed out readily. Let's suppose that the progress in illumination technique continues during the next two decades (which is quite probable). Does it mean that the recommendations will go up by another five times? This would clearly bring the recommended illumination to levels where, in all probability, a deterioration of performance and concomitant physiological reactions should be expected. This perspective makes a valid physiological foundation for the recommendations more important than ever.

Mr. Crouch pointed out to the future work sponsored by the I.E.S. which will take into consideration not only performance but also cost of work. This may imply that in our work only performance was taken into consideration. This, however, is not the case.

Cost of work, in the accepted energetic meaning of the term, can be exactly measured only in moderately heavy or heavy muscular work. In all types of visual work the increase of energy expenditure is too small to be precisely measurable, and in all likelihood is not due to the visual work as such but to the concomitant muscle tension.

Since the cost of work cannot be directly measured in visual work, some general physiological reactions are taken as representative for it. "Cost of work" is a somewhat loose expression in this context and may produce the illusion that one is actually able to measure the energy cost of vision. We have, therefore, avoided this expression, and preferred to discuss this approach under the somewhat less pretentious term of "fatigue trends in visual and non-visual functions." The terminology, however, is the only difference; we have measured concomitant reactions (*e.g.*, the blinking rate) in our own experiments, and we have discussed the advantages and limitations of this approach in the body of the paper.

We can go even further: there is no fundamental difference between fatigue trends of performance and concomitant reactions of visual or other functions. Decrement of work performance, therefore, seems to be more directly referable to "cost of work" than the more remote responses.

We wish to emphasize that our experimental work has not more than scratched the surface of a very intricate problem. It is relatively unimportant to which actual jobs our results are directly applicable. We believe that our *approach* provides a useful set of tools for further work which should be carried out on a much larger scale than we were able to undertake.

Such work is badly needed to provide firmer foundations for scientific "prescription" of lighting. One should clearly differentiate between light *requirements*, based on the physiological characteristics of the machinery of seeing, and *recommendations*. The latter will differ from the requirements, and will be influenced by technological and economic considerations, application of the elastic concept of a "safety factor," etc.

The physiological mechanisms involved in seeing are the resultant of a long evolutionary process and are much less affected by the passage of time than our ability to control the visual environment. This brings up the argument which is made quite often in the visual literature, and also by Mr. Crouch, that the outside daylight levels should be the goal of inside illumination since the human eye has become adapted to those levels in the process of evolution. It should be pointed out that the human eye is not adapted to any *particular* light level. On the contrary, the outstanding feature of the human eye is the tremendous range of light and dark adaptation, far exceeding the range of any other physiological adaptation mechanism. The only visual function where evolutionary adaptation to high brightness levels might be involved is the far distance acuity, which is of comparatively little importance for industrial jobs, which are performed for the most part at a short distance from the eye. In fact, Tiffin and Kuhn found a negative correlation between far distance acuity and performance efficiency in tasks requiring close vision.

As to Mr. Guth's discussion, we are happy to see that we are in agreement about most of the points, except that we stress the cardinal importance of the experimental study of the physiological relations between light and sight for the definition of illumination goals. The large material, accumulated by Luckiesh, Moss and their co-workers and successors, should not and cannot be ignored. However, the emphasis placed on short term visibility measurements should be corrected by other criteria. As a rule, *some* measurements are better than *no* measurements at all. Nevertheless, it should be recognized that recommendations based on any single criterion, limited in its validity, might be occasionally quite wrong. Even though the visibilometer has not been intended to provide *the* basis for lighting prescription, in practice it has been largely used that way. In the original literature the wide applicability rather than the limitations of this method has been stressed.

The I.E.S. has a unique opportunity for stimulating and supporting fundamental research designed to study, in a realistic context but under experimentally controlled conditions, the relationships between illumination and vision.

Erratum

The paper, "Air Diffusion and Light Depreciation Tests of a Luminous Ceiling," by R. C. Putnam, R. W. Waite, L. G. Seigel and W. L. Bryan, published on page 274 of the May 1952 issue of ILLUMINATING ENGINEERING, was not the paper presented at the Great Lakes Regional Conference, Cleveland, Ohio, May 6, as was erroneously stated in the footnote. The paper presented at Great Lakes was "Prospects of Light, Air and Sound Conditioning with Luminous Ceilings" by R. D. Burnham and R. Horner.

Questions and Answers on light sources

The I.E.S. Committee on Light Sources, under the chairmanship of E. H. Raddin, has prepared this listing of answers to frequently-asked questions. Readers are invited by the Committee to submit similar questions of general interest on light sources, to be considered for publication from time to time. Questions may be sent in care of Society Headquarters.

Does the color temperature of photographic tungsten filament lamps change during life?

Yes. Bulb blackening (evaporated tungsten) acts like a color temperature altering filter. The extent of the effect is influenced by the burning position of the lamp and how much of the useful light passes through the blackening. Since the average drop in color temperature, due to all causes, is usually less than 100 degrees Kelvin, it is customary to design such lamps so that the initial color temperatures average 30 to 50 K higher than the published value.

What is the effect on life and lumen output of lamps burning in varied positions?

In the case of standard fluorescent lamps burning position has relatively no effect on life and lumen output.

The lumen maintenance of most general service incandescent filament lamps will be affected by burning position. Some general service lamps and most special service lamps are designed for a particular burning position for best life and lumen maintenance, and the burning position is specified in the manufacturer's catalogue.

What would be the effect on silvered bowl lamps due to burning them in a base-down position?

The general effect would be a resulting poorer lumen maintenance. This is due, of course, to the fact that the blackening caused by filament evaporation would accumulate on the silvered part of the bulb, thereby materially reducing its reflecting properties and corresponding light output.

In the case of the smaller sizes, up to and including the 150-watt size, no particular temperature problems would develop. However, with the larger sizes, temperatures at the silvered portion of the bulb would exceed in most cases the values which the silvering may withstand, resulting in breakdown of the silvered surface accompanied by exceedingly poor lumen maintenance.

The life should not be affected seriously unless the lamps are so confined as to result in temperatures which would cause physical damage to the lamp.

What gases are used in fluorescent lamps?

In addition to mercury vapor, standard type fluorescent lamps generally are filled to a low pressure with argon, krypton, or neon, singly or in combination.

What temperature is usually found on the outside of hot cathode and cold cathode lamps using the same wattage per lineal foot?

Except in the immediate vicinity of the electrodes there is no difference of bulb wall temperature between hot and cold cathode lamps using the same wattage per lineal foot. This temperature is approximately 20F above the ambient. The temperature at the ends, in the vicinity of the cathodes, will be higher, with the cold cathode exceeding that of the hot cathode by about 60F.

Can the same cold cathode lamp be used for series or ballast operation?

Yes — all cold cathode lamps can be operated either from a proper ballast or in a series arrangement connected to a luminous-tube type transformer. The HP type lamp requires a higher starting voltage than the LP type. For example, the 93-inch T-8 type HP lamp requires a starting voltage of 835, while the equivalent LP lamp requires only 750 volts.

TELECAST

LIGHTING NEWS OF CURRENT INTEREST

H. H. Magdsick Awarded I.E.S. Gold Medal

The Society's highest honor—the I.E.S. Gold Medal—has this year been awarded to Herbert H. Magdsick of General Electric Co., Nela Park, Cleveland. The award was made by unanimous action of Council at its April meeting, on recommendation of the Medal Award Committee. Presentation of the Medal, together with an official citation, will be made to Mr. Magdsick at the National Technical Conference in Chicago next September.

Mr. Magdsick's qualifications for the award—"for meritorious achievement conspicuously furthering the profession, art or knowledge of illuminating engineering"—are acknowledged throughout the industry. He has been a distinguished figure in illuminating engineering for some 40 years. He has already received all other I.E.S. honors, including election to the office of President (1929-1930) and election as a Fellow (1945).

Mr. Magdsick was graduated in 1910 from the University of Wisconsin with a degree in Electrical Engineering, joining the National Electric Lamp Association at Cleveland the same year. In 1919 he was made Director of Commercial Engineering for the National Lamp Works of the General Electric Company, and in the consolidation with Edison Lamp Works became Executive Engineer in the Engineering Department.

He was notably successful in developing staffs widely known for their versatility and high competence in many fields of lighting, of both general and specialized character. Mr. Magdsick fostered numerous pioneer studies which established basic requirements and contributed fundamentals of an adequate technology for a variety of applications of visible, infrared, and ultraviolet radiation.

For many years, Mr. Magdsick had a special interest in promoting a more general appreciation of the range of talents and training for which the science, the art, and the business of lighting afford gratifying opportunity, so as to attract to this field men and women of appropriate qualifications and to help them achieve rewarding careers.

When the gas-filled incandescent lamp became available in 1914 he designed the pioneering floodlighting installations, including the Woolworth Tower and the Statue of Liberty. He likewise became a leader in establishing the new source as the dominant illuminant for streets, replacing the various forms of arc lamps previously employed.

In 1923 Mr. Magdsick conducted the first International Lighting Mission, giving representatives of several European and South American countries the opportunity for an extended first-hand study of American lighting activities. Thereupon he assisted in the organization of lighting education centers in Europe, including the one which subsequently became the ELMA Bureau in London.

In 1911 Mr. Magdsick joined the Illuminating Engineering Society of which he is now a Fellow. Responsibilities have included the chairmanship of such committees as Papers, Industrial and School Lighting, Motor Vehicle Lighting, Lighting Legislation, National Technical Conference, and I.E.S.-Beaux Arts Prize.

In 1929 Mr. Magdsick was elected President. His administration was characterized by marked growth in membership and a broadening of the Society's educational activity, with emphasis on the promotion of understanding and cooperation between architects and illuminating engineers. Among the approaches inaugurated to this end was a section devoted to Lighting in Architecture and Decoration, as a regular feature of the Society's Transactions. He further instituted largely attended week-long courses on architecture for illuminating engineers held in several parts of the country, with distinguished members of university faculties and the architectural profession serving as lecturers.

His Presidential Address at the Richmond Conference in 1930 pointed out the need for expanding the Society's Transactions into a journal reflecting more comprehensively the art of lighting and the related sciences, worldwide in its outlook and more attractive in presentation. The depression and war intervened, but in the administrations of Presidents Hardacre and Staud he was appointed Chairman of a Special Task Committee to bring such a program into being. ILLUMINATING ENGINEERING in its new expanded form represents an important step toward these objectives, which will be more fully realized as resources grow and staff is increased. He has continued to serve on the Publications Committee as Chairman of its Sub-Committee on Editorial Content.

H. H. Magdsick

Since 1929 Mr. Magdsick has been a member of the United States National Commitee of the International Commission on Illumination. In 1930 and 1931 he directed the Secretariat on Industrial and School Lighting, and participated also in the 1939 meeting in Holland. At present he serves as a member of the Committee on Scope, which has the task of rviewing and reorganizing the Commission's technical activities.

Memo to Members

Be sure to mail your registration blanks for the National Technical Conference, Chicago, Sept. 8-13 to headquarters office:
Illuminating Engineering Society
1860 Broadway
New York 23, N. Y.

PLANNERS of the Southern Regional Conference are, l. to r., R. C. Paslay, Regional V-P; S. B. LeCornu, Section Chairman, J. L. Sisk, of Nashville Electric Service and President S. G. Hibben, who made the keynote address.

Tennessee Valley Section Host For Southern Regional Conference

The highly successful Southern Regional Conference was held April 21-22 at the Hermitage Hotel, Nashville, Tenn. Over 150 delegates from the seven Sections and Chapters comprising the Region attended the two-day conference.

The keynote speech was given by I.E.S. President S. G. Hibben, who stressed the responsibility of the lighting industry in preventing eye strain. He outlined the growth and development of the industry since the Society was founded in 1906.

MONDAY SESSION

The conference opened bright and early Monday morning when the assembly was welcomed by The Honorable Gordon Browning, Governor of Tennessee and the Honorable Ben West, Mayor of Nashville, who were introduced by J. L. Sisk, of Nashville Electric Service. R. C. Paslay, Vice-President of the Southern Region, responded. S. B. LeCornu, Chairman of the Tennessee Valley Section, presided.

The session continued with:

Lighting a City's Streets to I.E.S. Standards —A Case History—J. H. Murrah, Georgia Power Co.

Artificial Lighting for Cotton Classing—Fred M. Nieli, Memphis Light, Gas and Water Division.

Afternoon—Norman E. Tindal, Chairman, Carolinas Chapter, presiding

The Ceiling Grid System—New Trend in Office and School Lighting—E. H. Church, Benjamin Electric Mfg. Co.

Studies in Utilizing and Controlling Daylight in Classrooms—Reta Lee, Georgia Power Co.

Mercury and Fluorescent Mercury Light Sources—W. S. Till, Westinghouse Electric Corp.

Discussion of the papers.

TUESDAY SESSIONS

Morning—T. Taylor Peake, Chairman, Georgia Section, presiding

A Tennessee Home in a New Light—May Love Gale, Tennessee Valley Authority.

Proposed Designs for Lighting Education in Home Economics Colleges—Kaye A. Leighton, General Electric Co.

Rural Applications of Lighting and Infrared Lamps—T. C. Sargent, Sylvania Electric Products, Inc.

Discussion of the papers.

SECTION Charter presented to Chairman LeCornu by President Hibben.

Afternoon—R. C. Paslay, Vice-President, Southern Region, presiding

Address—John Oliver, Tennessee Valley Authority.

Summation and Reports—Buford H. Martin, Chairman, Program and Papers.

ENTERTAINMENT

A reception was held Monday afternoon at Longacres, the home of Mr. and Mrs. Phillip Kerrigan, Jr. and a banquet and dance at the beautiful new Capitol Room at the Hermitage. At the banquet, at which Joe L. Booker, General Electric Supply Corp., presided, President Hibben presented the certificate of Section status to S. B. LeCornu, chairman of the Tennessee Valley group.

Alston Rogers staged and produced his demonstration, "Salute to Lighting Progress," which included such ideas for the future as lighting a cigarette with an infrared lamp.

The banquet hall in the Hermitage Hotel.

Fun for the Ladies

Tagged with "light bulb" corsages, the wives and guests of the delegates had their time fully occupied by social activities which took them from the hotel to the Hermitage, home of Andrew Jackson, from there to Hundred Oaks for luncheon, on to the beautiful gardens of the "Old Dirt Dobber," past the steeplechase grounds of Percy Warner Park and back by way of the Parthenon for inspection of its Greek architecture. They then joined the men for the reception and banquet.

Credits

Conference Chairman, Bulloch Taylor was aided by nine committees with chairmen as follows:

Program and Papers—Buford H. Martin
Hotel—Herschel B. Hall
Registration—J. L. Simpson, Jr.
Entertainment—Joe W. Fowler
Finance—Don McClearen
Publicity—Collin Finney
Decorations—Joe L. Booker
Transportation—Earl E. Parks
Ladies Entertainment—May Love Gale

Officers of the Tennessee Valley Section are S. B. LeCornu, Chairman, and W. E. Nash, Secretary.

Annual Spring Conference Held by Iowa Section

Site of the annual Spring conference, sponsored by the Iowa Section, I.E.S. and held April 25, was the Grant Wood School, Cedar Rapids, Iowa. The conference offered an opportunity to inspect the school and to hear the story of its planning.

The program opened with a call to order by Chester P. Stone, Chairman of the Section, and a welcome by Verne Lear of Cedar Rapids. Introduction was made by the Conference Chairman J. C. Young, Jr. The following topics were presented:

Grid Systems—A New Trend in School and Office Lighting—Eric H. Church, Benjamin Electric Mfg. Co.
Wiring—Its Importance in Commercial Lighting—Marshall A. Havenhill, Director, Lighting Institute, Kansas Light & Power Co.
Planning and Lighting of the Grant Wood School (Including a tour of the building—O. H. Breidert, Childs and Smith, Architects.

Discussion followed each of the speeches. After the technical program, a hospitality hour and banquet were held at the Roosevelt Hotel, with Donald Isett, Metropolitan Supply Co., guest speaker.

The Grant Wood School, occupied for the first time this past school year, has 21 classrooms, cafeteria, offices, etc. Its lighting system makes use of 40-watt T-17 low brightness fluorescent lamps. Architects for the building are Childs and Smith, Chicago.

Niagara Falls Site of Ninth Annual Canadian Regional Conference

Hamilton Chapter was the host group to the Canadian Regional Conference held April 30 through May 2, at Niagara Falls, Ontario. A roll call of members present disclosed that every Canadian group was represented, and in very respectable numbers from each Section. Total attendance was 175.

A resort site afforded the opportunity of an especially enjoyable program of entertainment, though many were content, between sessions, to sit on the patios opening off most of the rooms of the General Brock Hotel, and just look at the impressive view of Niagara.

Some of the tours planned in connection with the Conference included a conducted trip through the enormous power development project now under way by the Hydro Electric Power Commission of Ontario, with lunch at the Hydro Cafeteria.

Ladies Program

While the technical program was so arranged as to allow opportunity for delegates to get the most from the exceptional sights at Niagara Falls, a special program was arranged for visiting ladies. Sight-seeing tours included Table Rock, the Maid of the Mist, the Oneida Flat Silver plant, and bus tours on both the American and Canadian sides of Niagara Falls. Delegates and ladies joined for a special luncheon May 1st, in the Ball Room of the General Brock. Guest speaker at this meeting was Robert H. Saunders, Chairman of the Ontario Hydro-Electric Power Commission.

Another joint meeting affording special pleasure was a reception honoring I.E.S. President and Mrs. S. G. Hibben, followed by a dinner dance Thursday evening.

Technical Sessions

High spot of the Conference was of course, the well-attended technical sessions starting at nine each morning and continuing throughout the day. The opening session, with G. F. Mudgett, Conference Chairman presiding, was addressed by the I.E.S. President, S. G. Hibben who spoke on the Society's aims. F. P. Labey, Canadian Regional V.-P. gave the address of welcome. The technical sessions included the following papers:

"Design and Operation of Fluorescent and Slimline Ballasts"—N. A. George.
"Daylighting and the Classroom Environment"—by E. R. Wilbee.
"Some Problems of School Lighting"—by J. M. Charlton.
"Quality—Our Next Step in Industrial Lighting"—by George J. Taylor.
"Mercury Vapour Lighting in Industry"—by E. W. Beggs.
"Lighting for Hazardous Locations"—by K. V. Knudsen.

(Continued on page 9A)

AN ORIGINAL painting by the late G. G. Cousins was presented to the Society for Mrs. Cousins, during the luncheon session at the Canadian Regional Conference May 1, at Niagara Falls. I.E.S. President S. G. Hibben (left) accepts the gift. M. S. McHenry, Director of Consumer Service, Ontario Hydro Power Commission made the presentation. ***Photo courtesy Electrical Digest magazine, Toronto.***

Goings-On in the Sections and Chapters

Attendance was 78 when the Montreal Section and the Quebec Chapter "met each other half-way" at the mid-point city of Trois-Rivieres for a full-day session.

The Charter for the Louisiana Student Branch at Baton Rouge was recently presented to J. A. Loupe, Jr., Chairman, by R. Cecil Paslay, Vice-President of the Southern Region. Faculty Advisor, Professor W. D. Morris is an interested onlooker.

President Sam Hibben looks mighty "Rebel" in the Confederate cap and necktie presented to him at a meeting of the Georgia Section. With him are Mrs. Hibben, Mrs. Peake and Section Chairman T. Taylor Peake.

Members of the St. Louis Section attend a survey of the new lighting installation in the Pond Elementary School at Pond, Mo. Some of the 25 who were present are shown in the photograph above. Installation uses 40-watt low brightness units.

Officers and Committee Chairmen of the Chicago Section are, below, left to right: front row, A. P. Larson, Chairman, Public Relations and Publicity, C. A. Basedow, Manager and President of Study Club; center row, C. K. Lambka, Manager; J. R. Chambers, Secretary-Treasurer; R. R. Lusk, Chairman; W. A. Weibel, Vice-Chairman; W. K. LeBold, Manager and President of Residential Lighting Forum; standing, J. A. Harrington, I.E.S. Representative to Illinois Engineering Council; C. S. Zersen, Historian; C. B. Thorsen, Extension Chairman; C. W. Clarkson, Program Chairman; A. Eckel, Chairman, "My Most Interesting Lighting Job" contest.

The Colonial Room of the Detroit Leland Hotel was the site of the reunion meeting of the Michigan Section when 22 living past-chairmen of the Section were honored guests.

(Continued from page 7A)

"A Look into the I.E.S. Research and Technical Committees"—by C. L. Crouch.

"Developments in Mercury Vapour Street Lighting"—by E. B. Karns.

"New Developments in Light Sources"—by A. C. Barr.

ACKNOWLEDGMENTS

Many Canadian members joined efforts for many weeks to make this Conference the success it was. Much credit is due to these tireless workers, and especially the following:

G. F. Mudgett, Conference Chairman.

Serving as Session Coordinators:

C. M. MacGregor, Chairman, Hamilton Chapter.

J. A. I. Kidd, Chairman, Toronto Section.

T. W. Birt, Chairman, Winnipeg Chapter.

E. L. MacElmon, Chairman, Maritime Chapter.

F. W. New, Conference Secretary.

D. F. Davis, Papers Chairman.

E. L. Doddington, Entertainment and Hotel Chairman.

G. M. Whittaker, Finance.

J. M. Smithells, Publicity.

J. D. Harrison, Registration.

J. M. Wickett, General Committee Chairman.

E. E. Morris, Chairman, Montreal Section.

J. H. Rylance, Chairman, Ottawa Chapter.

Romeo Martineau, Chairman, Quebec Chapter.

IDEAS WORTH STEALING

The Canadian Regional planners had an idea worth copying in future conferences. 1. Separate tickets for each event bound in a small book. Collection of these aided in counting noses. Price of the event on each ticket subtly explained the registration fee.

One footcandle Decoration on tables at Great Lakes Regional Conference.

Great Lakes Regional Conference

Double Header with I.L.E.

The Great Lakes Conference, Hotel Statler, Cleveland May 5 and 6, was billed as a lighting double-header, since its final session overlapped with the Fourth International Lighting Exposition May 6-9. The first game was a big one. Some 300 people attended. Its excellence was not in size only, however. Technical sessions were heavily attended; discussions of the papers well organized; the entertainment and ladies program particularly well planned and conducted.

TECHNICAL PROGRAM

Technical sessions commenced Monday, May 5 with an address of welcome by the Hon. Thomas A. Burke, Mayor of Cleveland. The delegates also heard an address by I.E.S. President S. G. Hibben and greetings by F. C. Winkler, Regional V. P.

Chairman for the first session was G. H. Seiter, Chairman of the Ohio Valley Section, with Neal Jacobus, Western New York Section Chairman, serving as Discussion Leader. Papers presented were:

"What Goes Into Good Design," by J. M. Ketch.

"The Architect and Lighting," by Neal Jackson and R. W. Brown.

Luncheon Address, Geo. A. Bowie.

Chairman of the next technical session was H. G. Locke, Chairman of the Rochester Section; Discussion Leader was R. N. Green, Cleveland Section Chairman. These papers included:

"New Lamps, New Lamp Data," by A. C. Barr.

"More and Better Ballasts," by C. H. Burns.

"Are Comfort Rating Systems Ready," by Ward Harrison.

"Why Color and Which Ones Where," by W. C. Granville and T. C. Sargent.

Tuesday morning session was under the direction of Prof. C. L. Cottrell, Central New York Section Chairman, Dr. M. H. Bigelow, Chairman of Northwestern Ohio Chapter, serving as Discussion Leader. The papers were:

"Louverall and the Occupancy Module at Detroit Edison," by L. E. Tayler.

"Prospects of Light, Air and Sound Conditioning with Luminous Ceilings," by R. D. Burnham and R. Horner.

"Improving the Quality of Industrial Lighting," by G. J. Taylor.

Following the morning sessions, the delegates joined a grand march to the Public Auditorium to be on the stage for the official opening of the International Lighting Exposition.

MOST INTERESTING JOB CONTEST

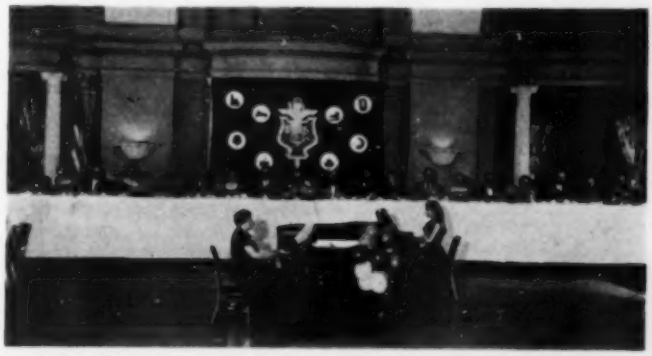
Final session of the Conference was the presentation by six contestants of "My Most Interesting Lighting Installation," the contestants being first place winners in the local contests conducted earlier by their own Sections.

First prize was taken by Earl R. Domoney, Consumers Power Co., Saginaw, Michigan for his unique job in relighting an old church. Mr. Domoney now qualifies as a finalist in the competition of the Lighting Service Forum at Chicago next September.

Second prize went to Alan R. Cripe of the Chesapeake & Ohio Railroad for his lighting of a private railroad car. Robert W. Brown of Cincinnati Gas & Electric Co. was third with his installation at the Kroger Co. executive offices. Mrs. Winifred C. Erdle of Beman and Candee, Buffalo, won honorable mention for an excellent installation in the library of the Buffalo State Teachers College.

Judges for the contest were: Dr. Ward Harrison, S. G. Hibben, C. L. Crouch,

(Continued on page 11A)



HEAD TABLE — Decorations on panel behind table represent each of the eight Sections and Chapters in the Great Lakes Region.

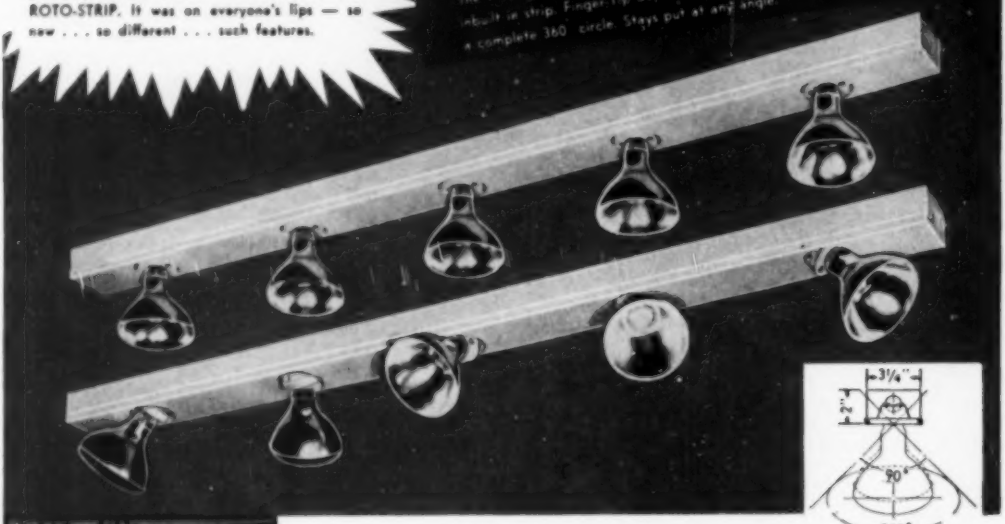
THE HIT OF THE SHOW

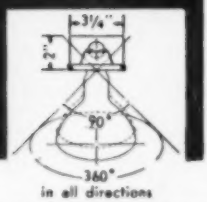
If you were at the 4th International Lighting Exposition you saw it . . . if you weren't you probably heard about it — the new NEO-RAY ROTO-STRIP. It was on everyone's lips — so new . . . so different . . . such features.

An Entirely New Development in Display Lighting

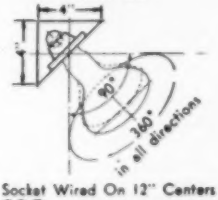
NEO-RAY **ROTO STRIP**

The first — the only — complete compact shallow unit—swivel sockets built in strip. Finger-Tip adjustment—swivels 90° in all directions through a complete 360° circle. Stays put at any angle.

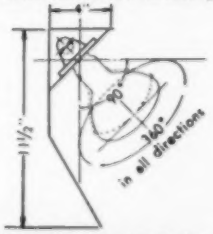




Socket Wired On 12" Centers
No. 13



Socket Wired On 12" Centers
No. 13C For Corner Mounting



Socket Wired On 12" Centers
No. 13R with Reflector

For Window Lighting, Rug Displays, Stock Bins, Jewelry Counters, Wall Cases, Murals, Floor Displays, Signs, etc. Ideal for anything that calls for highlighting.

- In stock sizes 2'-3'-5' and 8 ft. lengths. These stock sizes may be combined for any desired length:
  EXAMPLE: For 47 ft. . . . 5-8 ft. lengths
  1-5 ft. length
  1-2 ft. length
- Sockets wired 12" center to center, start 6" from end.
- K.O.'s on top and ends.
- Can be suspended with our No. 10 Hanging Assembly.
- Low cost installation—one Roto-Strip with 8 sockets installed in same time as single ordinary socket.
- Rugged one piece high temperature resistant socket.

Write for Complete Literature

NEO-RAY PRODUCTS, INC.

Manufacturers of Lighting Equipment • Incandescent • Fluorescent • Slimline

315 EAST 22nd ST. • NEW YORK 10, N. Y.

(Continued from page 9A)

Prof. R. C. Putnam and Paul H. Hildebrand.

Radio and Television

The stature of the Great Lakes Conference was reflected in the interest shown by the local press, radio and television. President Hibben was interviewed on television May 5, by the well-known news analyst, Dorothy Fuldheim. Mr. George Bowie's talk before the members luncheon on Monday was tape-recorded and broadcast on radio that evening. A tape recording was rebroadcast also on Monday featuring a round table discussion between Mr. Hibben, Mr. Walter Sturrock and Prof. E. M. Strong. Mr. and Mrs. Hibben were interviewed over WTAM by Gloria Brown and Mildred Funnel of that station.

Entertainment

High spot of the entertainment program was the President's Reception and dinner-dance Monday evening. Here again, planning and effort paid off in the smooth handling of many people, extraordinarily clever decoration, and fun in general. The amusing table decorations were three-dimensional footcandles, 5 x 2 inches in size, cast by Mrs. K. A. Staley from a design by the Cleveland Institute of Art, and decorated in various colors.

During dinner the guests were entertained with a two-piano concert by Mrs. Joseph Terr and Miss Joan Terr, the talented wife and daughter of one of Cleveland Section's most active members. This feature was especially pleasant during dinner and was greatly enjoyed. Following dinner, fresh young voices of the a capella choir of Cleveland Heights High School harmonized in a number of selections. The choir, presently on its way to perform in Europe was under the direction of George Strickland.

Mr. Hibben was presented with an electric mixer by the Great Lakes Region, who gave as a reason that he was such a "good mixer."

The ladies' program was also smoothly organized, with Cleveland wives serving as hostesses for brunch parties, style shows, shopping expeditions. Visiting ladies were entertained at tea Monday afternoon at the home of Mrs. Ward Harrison.

Acknowledgments

Committee members responsible for this fine conference were:

Honorary Chairman ..... F. C. Winkler
Chairman ..... C. L. Amick
Vice-Chairman ..... R. N. Green
Secretary-Treasurer ..... F. E. Mueller
Transportation ..... Allen Schwartz
Ladies (Co-Chairman) .... Mrs. F. E. Mueller
Mrs. W. H. Kahler
Mrs. A. B. Oday

ROUND TABLE discussion by Prof. E. M. Strong, Walter Sturrock and S. G. Hibben was broadcast over WGAR on the afternoon of May 5.

Papers and Program Committee
R. L. Oetting, Chairman

R. E. Birr	V. D. Mitchell
J. F. Buckley	L. A. Niemeyer
C. N. Clark	A. C. Sangster
Rose M. Coakley	H. S. Scott
C. L. Cottrell	W. P. Werner
W. V. Misrach	T. J. Wood

Attendance and Publicity
J. J. Neidhart, Chairman

G. R. Baumgartner	H. J. McCullough
Dorothy Bolyard	L. W. O'Brien
A. S. Kraut	W. A. Porterfield

J. L. Wolf

Hotel
F. L. Detwiler, Chairman
J. T. Yelding

Displays and Decoration
Winifred L. Fay, Chairman

Joseph Gerengher	Kaye A. Leighton
A. D. Harrington	H. E. Lippman
E. O. Kessman	C. A. Oerkvitz

Registration and Reception
R. M. Smart, Chairman

Charles W. Craig	S. A. Eisenberg
E. I. Creed	E. M. Kocker
A. A. Eastman	Charlene B. Reed

Entertainment
R. W. Butts, Chairman

C. E. Egeler	R. F. Hartenstein
K. R. Eppele	H. A. Lawrence

Joseph Terr

Ladies' Program Hostesses

Transportation
Mrs. Homer A. Lawrence
Mrs. Norman H. Vacha

Decorations
Mrs. J. William Steiner

Monday—Shoppers' Brunch
Mrs. F.E. Mueller, Chairman

Mrs. G. R. Baumgartner	Mrs. R. L. Oetting
Mrs. F. L. Detwiler	Mrs. Allen Schwartz
Mrs. A. A. Eastman	Mrs. R. M. Smart
Mrs. A. D. Harrington	Mrs. Joseph Terr
Mrs. H. A. Lawrence	Mrs. J. L. Wolf

Monday—Tea
Mrs. Arthur B. Oday, Chairman

Mrs. C. L. Amick	Mrs. R. F. Hartenstein
Mrs. W. C. Brown	Mrs. M. Lackiesh
Mrs. R. W. Butts	Mrs. W. Sturrock
Mrs. R. N. Green	Mrs. A. F. Wakefield

Tuesday—Luncheon
Mrs. William H. Kahler, Chairman

Mrs. B. S. Burke	Mrs. J. J. Neidhart
Mrs. L. J. Cahill	Mrs. D. W. Rowten
Mrs. E. C. Huerkamp	Mrs. J. Wm. Steiner
Mrs. R. W. Morris	Mrs. S. E. Strunk
Mrs. W. C. Mutchler	Mrs. J. T. Yelding

Ideas Worth Stealing

Ideas worth swiping from the Great Lakes Conference: 1. Pre-billing and plenty of advance notices and publicity. 2. Advance arrangements with radio and press. 3. Original and appropriate decorations at the dance. Behind the speakers' table a large fabric panel featured a trans-illuminated Society emblem (made locally) and trans-illuminated scenes representing each Section of the Region. For instance, chair for Grand Rapids; automobile, Michigan; camera, Rochester; Indian, Cleveland; glass, Toledo; river boat, Cincinnati; street lighting, Syracuse; honeymooners, Buffalo. 4. Organization of discussors at papers sessions. 5. Diversification of responsibility.

Quebec and Montreal Groups Meet at Trois-Rivieres

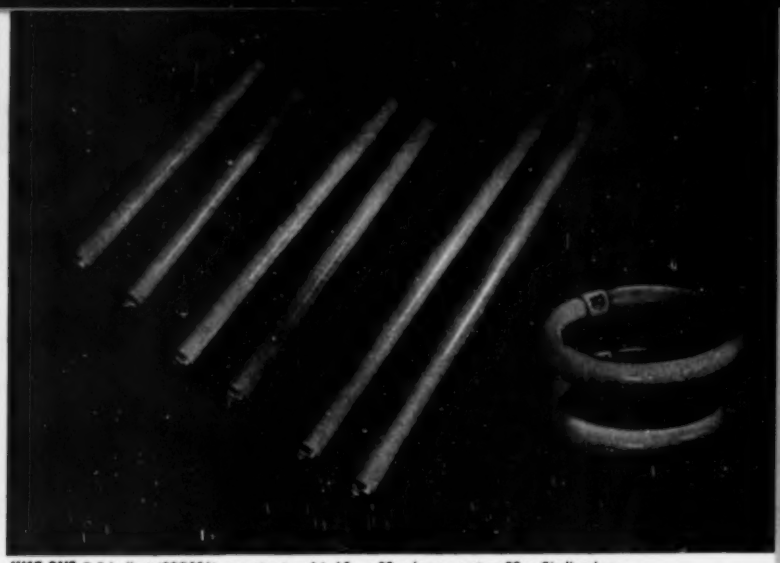
Members of the Quebec Chapter and Montreal Section met with members from Trois-Rivieres for a total of 78 in attendance at a full-day session at the St. Mauriac Hotel.

The proceedings began with a tour of the Canadian Westinghouse lamp factory

(Continued on page 14A)

G-E ballast No. 89G332 for 32-w Circline lamp.

NEW: Ballast 89G322 for 22-w Circline lamp.



JUST ONE G-E ballast (89G331) operates two 14, 15, or 20-w lamps, or two 22-w Circline lamps.

More fixture designs possible

Now—make residential fixtures with all the above lamps and combinations—without using starters!

For the first time you can make fixtures using all of the above lamps and lamp combinations—*without using external starters*—with General Electric's expanded line of Trigger-Start Ballasts!

EXPAND YOUR MARKET

Your fluorescent fixtures will sell easier and faster because of the great customer appeal of G-E Trigger-Start Ballasts. They start lamps instantly without flickering, and they remove the bother of replacing worn-out starters. Moreover, these ballasts conserve lamp life because of their unique operation: electrodes are immediately pre-heated at the flick of the switch, then starting current drops to practically zero when the lamp goes on—almost faster than the eye can see!

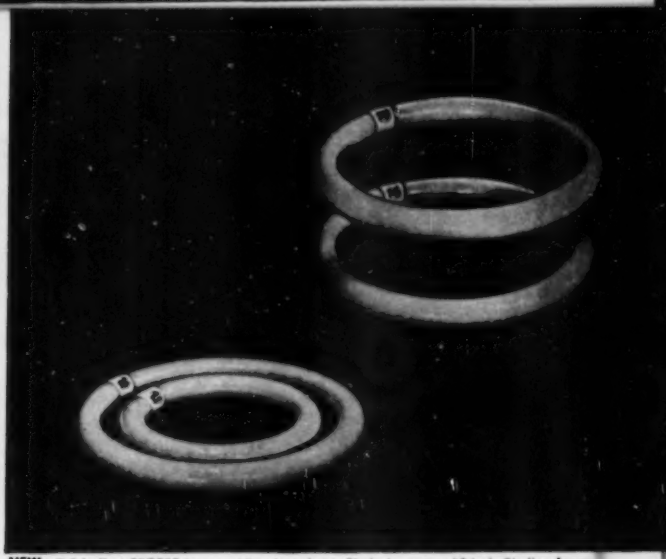
REDUCE STOCK PROBLEMS

Note that only five different G-E Trigger-Start Ballasts are needed to operate all of the above lamps and combinations. And, of course, there's no need to stock starters for trigger-start ballasts.

For more information on G-E Trigger-Start Ballasts contact your local G-E Sales Office, or write *Section 412-98, General Electric Co., Schenectady 5, New York.*

GENERAL ELECTRIC

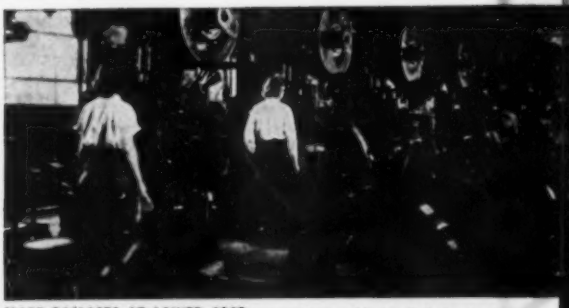
ONE G-E ballast (89G320) for 14, 15, or 20-w lamps.



NEW: G-E ballast 89G333 for one 12-inch and one 8½-inch, or two 12-inch Circline lamps.

with G-E Trigger-Start Ballasts

BETTER BALLASTS to help you build your fluorescent trade are continually being developed by G.E.—world's largest producer of ballasts. Above, G-E engineers work out new ballast design.



MORE BALLASTS AT LOWER COST are made possible by G-E standardization and mass-production methods. Above are automatic punch presses for cutting core laminations in G-E Danville (Ill.) Plant.

TOP PERFORMANCE is the result of continuing study of fixture manufacturers' problems and actual ballast operation.

YOUR ASSURANCE of a good ballast every time you buy G-E is automatic testing apparatus on the production line.

(Continued from page 11A)

under the direction of James Buntain, manager and Victor Guay, plant engineer. A reception was then followed by dinner in the hotel ballroom, with Romeo Martineau, chairman of the Quebec Chapter in the chair. Guest speaker Victor Guay, gave an interesting talk on the lamp factory history. All three cities represented were pleased with the splendid cooperation in making the joint meeting possible and expressed a desire to repeat it.

Milwaukee Spring Conference Features Lighting and Production

"Lighting—a Production Tool. Is it used wisely in your plant?" was the theme of the fourth annual Spring conference, May 14, sponsored by the Milwaukee Section, I.E.S. The full-day program was planned for plant engineers, maintenance engineers, electrical contractors, safety directors, jobber representatives, manufacturer's representatives and lighting specialists. Topics and speakers were:

New Developments in Light Sources—T. C. Sargent, Sylvania Electric Products Inc., Chairman of the I.E.S. Lighting Progress Committee.

How Is Lighting Used in Industry Today?—Benjamin Benson, Benjamin Electric Mfg. Co.

Does "Color" Apply to Industry?—Walter Granville, Container Corp. of America.

Fundamental Factors in Cost Comparisons—Charles Amick, General Electric Lamp Division.

Good Maintenance—What Does It Mean?—Carl Jenson, Westinghouse Electric Corp.

Luncheon was held in the Marine Dining Room of the Milwaukee Elks Club and at the conclusion of the afternoon session a buffet supper was held at the Blatz Brewing Co. Hospitality Room.

Visual Research Specialists Hold Three-Day Conference

Twenty three research scientists and specialists from universities in the United States and Canada attended a three-day Visual Research Conference, April 21-23, at the General Electric Lighting Institute, Nela Park. The conference marked the second of its kind, the first having been held in 1950.

S. K. Guth, in charge of Lighting Research at Nela Park; Willard C. Brown, manager of Application Engineering, and A. A. Eastman, research specialist, were co-chairmen in planning the conference.

The first day's session was concerned with "The Color Factor in Seeing." Discussion leader was Dr. Harry Helson of the University of Texas. Dr. Helson called attention to the fact that the eye does not see colored pictures or scenes as the camera does, but is greatly influenced by its adaptation level to the various color components present.

Dr. Helson stated that a method had been developed under the I.E.S. Research Fund sponsorship, whereby the appearance of object colors could be predicted under any illuminant if its spectral distribution be known.

Dr. Helson stated that the reaction of the intellect and emotions to color is hard to quantify. Therefore color preference studies in the laboratory may have little relation to life conditions. Reactions in life may depend largely upon behavior characteristics, such as satiation with a given color and a desire for contrast.

Keynote of the second session was "Efficient Seeing" and Dr. H. Richard Blackwell was the discussion leader. Dr. Blackwell first defined "efficient seeing" as maximum performance with minimal stimulus. Performance is considered largely in terms of (1) at threshold and (2) under supra-threshold conditions. Dr. Blackwell developed a case for the desirability of "forced choice" on the part of the observer in determining threshold performance. He stated that under this method relative judgment is largely eliminated and truer organism response curves are obtained which do not vary from day to day. He indicated that studies had developed the concept that all psychophysical performance curves are of one type in much the shape of a slanting "S." He stated that in recent studies, under the I.E.S. Research Fund sponsorship, he had determined the threshold curves for round disc test objects from 1' size to 64' and for varying contrasts and times of exposure as related to brightness level. From these threshold performance curves it is the hope to develop the illumination required for a given set of conditions in the field.

The subject for the third day's discussion was "Visual Fatigue" with Dr. S. Howard Bartley as discussion leader. Dr. Bartley stated that "fatigue had come to mean a great many things with many times a poor connotation. He described "productivity fatigue," "subjective fatigue," "physiologically indicated fatigue" and "combat fatigue." He categorized visual fatigue as (1) sensory, (2) ergographic, (3) systematic, (4) ease of seeing and (5) conflict, and gave illustrations and work done in each.

Discussions followed each day's presentation and much constructive comment added to the inspiration of the conference. A feeling prevailed as the meeting drew to a close that it had been most beneficial to discuss the latest results of visual research as it related to light and vision. An expression of approval was made to the Nela Park hosts.

PRESENT at the Visual Research Conference were, 23 research scientists and specialists. Seated are C. L. Cottrell, R. C. Putnam, L. C. Mead, Joseph Tiffin, Harry Helson, D. E. Spencer, R. M. Hall, S. H. Bartley, K. B. Stoddard, E. M. Strong; standing are S. K. Guth, Dean Farnsworth, C. L. Crouch, A. D. Ruedemann, L. H. Brown, R. H. Peckham, G. A. Fry, H. W. Hofstetter, H. R. Blackwell, M. A. Tinker, Ernst Wolf, A. A. Eastman. Missing from photo are D. Y. Solandt and Richard Feinberg.

"I.E.S. Day" Program At Duke University

The Carolinas Chapter and Duke University recently celebrated an "I.E.S. Day." Featured in the program was the inspection of the new Van de Graaf Accelerator in the Physics Building. This machine is the only one of its kind in the South which generates X-rays at 4,000,000 volts.

Dr. George Collier, Psychology Dept., Duke University, spoke on "Problems at Visual Thresholds," and T. A. Boyd, Consultant for General Motors Research Laboratory had as a topic "Trail Blazing in Industry."

(Continued on page 17A)

THE OLD WAY:
strong contrast
deep shadows

the
GUTH WYTE-LINER WAY:
low contrast
soft shadows

Here's a new idea in factory lighting to lift the eyestraining gloom off the ceiling:

ALL WHITE INSIDE—to reflect maximum light down and outward onto the working area.

ALL WHITE OUTSIDE—to reflect room light upward, brighten the ceiling and soften brightness contrast.

Easier to clean—reduces maintenance. Airflow Channel circulates air currents for longer ballast life.

GUTH Wyte-Liners are made in 2 and 3 lamp sizes for conventional 40-watt lamps and for 4- and 8-ft. Slimline. May we send you our 16-page Catalog 48-1 with complete details?

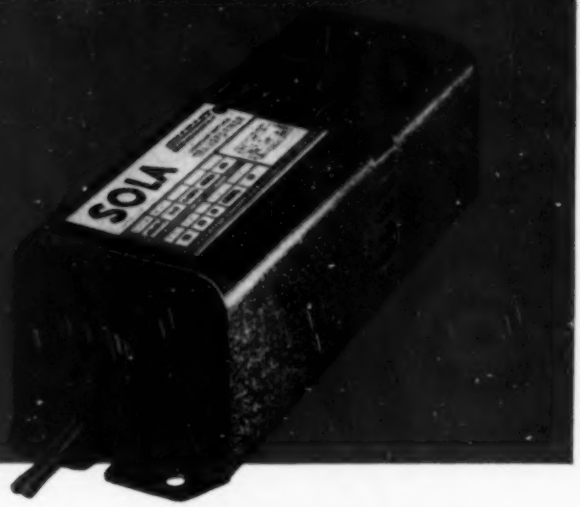
Guth LIGHTING

THE EDWIN F. GUTH COMPANY / ST. LOUIS 3, MISSOURI

Leaders in Lighting since 1902

another NEW SOLA ballast development

Dynatran
TRADEMARK
BALLASTS



The LIGHTEST and SMALLEST LEAD-LAG BALLAST* ever produced

Here is the answer to your fluorescent lighting problems. A new premium performance ballast that is outstanding. It is comparable in size and wattage loss to current models of certified "Sequenstart" ballasts. *The new Dynatran is certified by E. T. L. to comply with the present Spec. #6, and the proposed American Standards Association specification C82.1. It provides these advantages:

- *Independent lamp operation*
- *Small size, light weight*
- *High starting current*
- *Fast lamp starting*
- *Low wattage loss*
- *Low peak to R. M. S. current ratio*
- *More Lumens per watt*
- *Cool operation and low temperature rise*
- *Ventilated capacitor compartment for longer ballast life*
- *Quiet operation*
- *Stroboscopic correction*
- *Low Cost*

Designed in the tradition of Sola engineering leadership

SOLA *Fluorescent* BALLASTS

CERTIFIED E.T.L. SPEC NO 6

Transformers for: Constant Voltage • Fluorescent Lighting • Cold Cathode Lighting • Airport Lighting • Series Lighting • Luminous Tube Signs Oil Burner Ignition • X-Ray • Power • Controls • Signal Systems • etc. • SOLA ELECTRIC CO., 4633 W. 16th Street, Chicago 50, Illinois New York: 103 E. 125th St., New York 35, N.Y., TRafalgar 6-6464 • Cleveland: 1010 Euclid Ave., Cleveland 15, O., PRospect 1-4005

(Continued from page 14A)

In the evening, a joint meeting was held with the local group of A.I.E.E., when the demonstration lecture was on "New Applications of Photo-Cell Control" by Russell Ranson, of Ranson and Wallace, Charlotte, N. C.

Summary of Action by Council Executive Committee

A meeting of the Council Executive Committee of I.E.S. was held May 7 at the Hotel Statler, Cleveland, Ohio. Present were: S. G. Hibben, President, presiding; Vice-President, E. M. Strong; General Secretary, C. C. Keller; Treasurer, R. F. Hartenstein; A. D. Hinckley, Executive Secretary; C. L. Crouch, Technical Director; Ruby Redford, Editor; and G. B. Buck II, R. N. Green, K. E. Hollingsworth, Harold Rankin, Kirk M. Reid, Dana W. Rowten, Alfred C. Sangster, C. C. Shotwell, Walter Sturrock, John S. Walsh, F. C. Winkler.

Action was taken approving a number of additional committee appointments, including the establishment of a new task committee to study and recommend to Council the scope and personnel of a committee to cooperate with safety organizations. Scope of a sub-committee on Color, of the Light Sources Committee was also directed.

Membership

Action taken on the report submitted by the General Board of Examiners, E. M. Fahey, Chairman, confirmed the election of 137 Associate Members, 31 Members, and 21 Students. Membership totals, as reported by the General Secretary are shown in the following tabulation:

September 30, 1951		May 7, 1952
7166	Total Membership	7600
32	Members Emeritus	33*
42	Fellows	43
1709	Members	1788
5174	Associate Members	5455
209	Student Members	281

*Includes 10 Fellows.

New Student Branches

Petition for Charter was made by R. C. Paslay, Southern Regional V.P., for a Student Branch at the University of Miami. Favorable action by the Committee approved the petition for a Charter at the University of Miami, with Prof. Jackson S. Sells serving as Branch Advisor.

A report was also given on the organization of an Illumination Club at the Southern College of Optometry, Memphis, Tenn. Activities of this group are under the direction of Dr. M. E. Brown as Advisor, looking toward the establishment of a Student Branch of the Society.

New Mexico Chapter

In the absence of W. E. Folsom, Regional Vice-President, G. B. Buck, II, Chairman of the Rocky Mountain Section, presented the petition of a group of members in and near Albuquerque, New Mexico, requesting authorization of a charter for a new Chapter. Mr. Buck stated that the petitioning group meets all of the Constitutional requirements and that the proposed Chapter area has been released by the Rocky Mountain Section. Following presentation action was taken to recommend to Council authorization of a charter for the New Mexico Chapter with headquarters at Albuquerque, including as the Chapter area, the State of New Mexico, subject to

(Continued on page 19A)

LIGHTING CALENDAR

Society Events

June 18, 1952 — Meeting of I.E.S. Council, Hotel Preston, Swampscott, Mass.

June 19-20, 1952 — Northeastern Regional Conference, Hotel Preston, Swampscott, Mass.

July 10, 1952 — Meeting of I.E.S. Council Executive Committee.

September 8-13, 1952 — Illuminating Engineering Society, National Technical Conference, Edgewater Beach Hotel, Chicago, Ill.

Industry Events

June 8-21, 1952 — International Organization for Standardization (ISO), General Assembly, Council and a Number of Technical Committees, Columbia University, New York, N. Y.

Week of June 9, 1952 — 44th Annual Convention, National Association of Eelectrical Distributors, Atlantic City, N. J.

June 9-13, 1952 — Third Annual Conference on Industrial Research, Columbia University.

June 16-18, 1952 — American Society of Heating and Ventilating Engineers, Semi-Annual Meeting, The Essex and Sussex, Spring Lake, N. J.

June 23-27, 1952 — Summer General Meeting, American Institute of Electrical Engineers, Hotel Nicollet, Minneapolis, Minn.

Week of June 30, 1952 — American Society for Testing Materials, 50th Anniversary Meeting, Hotels Statler and New Yorker, New York, N. Y.

June 30 - July 2, 1952 — Canadian Electrical Association, Annual Convention, Banff Springs Hotel, Banff, Alta.

June 29 - July 7, 1952 — New York State Association of Electrical Contractors and Dealers, Inc., Saranac Inn, Saranac, N. Y.

July 6-11, 1952 — New York Lamp Show, Hotel New Yorker, New York, N. Y.

August 18-22, 1952 — Pacific General Meeting, American Institute of Electrical Engineers, Phoenix, Ariz.

September 8-10, 1952 — American Standards Association's Third National Standardization Conference, Museum of Science and Industry, Chicago, Ill.

September 8-11, 1952 — Institute of Traffic Engineers, Annual Meeting, Hotel Sherman, Chicago, Ill.

September 29 - October 2, 1952 — Annual Convention, International Municipal Signal Association, Inc., Hotel Statler, Boston, Mass.

October 1-3, 1952 — Canadian Electrical Manufacturers Association, 8th Annual Meeting, General Brock Hotel, Niagara Falls, Ontario.

October 1-4, 1952 — 17th Annual Conference, International Association of Electrical Leagues, Radisson Hotel, Minneapolis, Minn.

October 7-9, 1952 — Pacific Coast Regional Restaurant Convention and Exposition, Biltmore Hotel, Los Angeles, Calif.

October 13-17, 1952 — Fall General Meeting, American Institute of Electrical Engineers, New Orleans, La.

October 20-21, 1952 — National Farm Electrification Conference, Hotel Statler, Detroit, Mich.

October 20-24, 1952 — 40th National Safety Congress & Exposition of the National Safety Council, Chicago, Ill.

November 10-13, 1952 — National Electrical Manufacturers Association, Haddon Hall Hotel, Atlantic City, N. J.

November 17-19, 1952 — 39th National Foreign Trade Convention, Waldorf-Astoria Hotel, New York, N. Y.

November 19, 1952 — 34th Annual Meeting, American Standards Association, Waldorf-Astoria Hotel, New York, N. Y.

January 19-23, 1953 — Winter General Meeting, American Institute of Electrical Engineers, New York, N. Y.

March 9-12, 1953 — National Electrical Manufacturers Association, Edgewater Beach Hotel, Chicago, Ill.

Week of May 24, 1953 — 45th Annual Convention, National Association of Electrical Distributors, Stevens Hotel, Chicago, Ill.

June 29 - July 3, 1953 — Summer General Meeting, American Institute of Electrical Engineers, Atlantic City, N. J.

August 18-21, 1953 — Pacific General Meeting, American Institute of Electrical Engineers, Vancouver, B. C.

September 21-26, 1953 — 25th Jubilee Meeting, International Association of Electrical Inspectors, Edgewater Beach Hotel, Chicago, Ill.

November 9-12, 1953 — National Electrical Manufacturers Association, Haddon Hall Hotel, Atlantic City, N. J.

While the city sleeps . . .

Leader LIGHTING FOR INDUSTRY

UCOP-3

NEW *Diffuser Unit*—Designed to modify the contrast between lighted work areas and upper dark areas. 7% indirect lighting component. All-steel construction. For 2 or 3 40-watt lamps, in open or closed end models. Porcelain reflector if desired.

240

Other Leader industrial units are available in open and closed end styles, for 2 or 3 40-watt, 2 85-watt, for 2, 3 or 4 slimline lamps. Rugged construction, many convenient features, choice of mounting. Write for complete information. No obligation.

• . . . industry hums, with the production of vital defense materiél, the manufacture of more and better products to meet America's expanding needs. Lighting plays an indispensable part in maintaining production at continuously high levels . . . and Leader plays an importat role in providing proper lighting for industrial production. The Leader line includes fixtures for all general and many specialized industrial requirements . . . and all units afford top performance, ease and flexibility of installation, economy in first cost and maintenance.

Sold and installed by the better electrical wholesalers and contractors

Leader *America's No. 1 Lighting Equipment Manufacturer*

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Leader Electric—Western: 800 One Hundredth Avenue, Oakland 3, California
Campbell-Leader, Ltd.—Brantford, Ontario, Canada

(Continued from page 17A)

the approval of the Regional Vice-President and the submission of By-Laws conforming to the Society's Constitution and By-Laws.

SOUTHERN COLORADO CHAPTER

Mr. Buck also presented the petition of a group of members in and near Pueblo, Colorado, requesting approval of a charter for the Southern Colorado Chapter. Mr. Buck stated that the petitioning group would meet the requirements stated in the Constitution following favorable action on the election of a number of members for whom he submitted membership applications.

Following presentation, action was taken to recommend to Council approval of a charter for the Southern Colorado Chapter, subject to the meeting of Constitutional requirements, the submission of By-Laws conforming to the Society's Constitution and By-Laws including a specification by Counties of the Chapter area, the official release of this area by the Rocky Mountain Section and the official approval of W. E. Folsom, Regional Vice-President.

NEW SUSTAINING MEMBERS

C. C. Shotwell, Chairman, presented for Council's approval the reinstatement of two Sustaining Members and the election of two new Sustaining Members. Following presentation action was taken to approve the committee's recommendations as follows:

Compco Corporation
2251 W. St. Paul
Chicago 47, Illinois
Official Representative: Lawrence H. Wrobel

Duray Fluorescent Mfg. Co.
3552 N. Pulaski Road
Chicago, Illinois
Official Representative: Ludwig Dannenberg

William Penn Fluorescent Light Mfrs.
1428 South 23rd Street
Philadelphia 46, Pa.
Official Representative: Pat Pedicone

Esty Manufacturing Company
1231 W. Monroe Street
Chicago 6, Illinois
Official Representative: Ben Trossman

Floating Power Plant Built by Navy

A 34,500-kilowatt floating power plant is being built by the U. S. Navy, which will be able to supply power needs of most naval shipyards or overseas bases. Three 11,500kw steam turbines will be installed in the MS Coastal Racer, a C1-M-AV1 design hull with length of 338 feet and 50-foot beam. The unit will be without propulsion power and will be towed to stations when needed.

ARCHITECTURAL STUDENT Lighting Design Competition award winners in the Southern California Section contest are, left to right: Charles G. Kanner, 1st prize; James W. Bird, 2nd prize; Wm. S. Lewis, 3rd prize; G. L. Payne, Trophy Design winner; and three Honorable Mentions, Henry Yen Foon, Merle A. Rousellot and Kenneth G. Bristol.

Architectural Student Awards Made at Joint I.E.S.-A.I.A. Meeting

The winners of the Architectural Student Design Competition awards, sponsored by the Southern California Section, were announced at a joint dinner-meeting April 2, of the Section and the local A.I.A. group. The winners are:

First prize—Chas. G. Kanner—$100.
Second prize—James W. Bird—$50.
Third prize—Wm. S. Lewis—$25.
Trophy Design Winner—G. L. Payne—$10.
Honorable Mention—Henry Yen Foon, Merle A. Rousellot, Kenneth G. Bristol—Certificate of Merit and one year's Student Membership in the I.E.S.

An additional prize winner has been admitted to the customary group, called "Permanent Trophy Design." This is a copper plaque on which will be inscribed the yearly winners of the competition, to be mounted on a cement base and erected in the patio of the U.S.C. School of Architecture.

Charles B. Fry, president, A.I.A. Southern California Chapter, spoke on the importance of the fine relationship between the respective local groups and said "Architects are very conscious of the effect which good lighting plays in the successful interpretation of their designs. In the development of the design, the architect must consider and plan for the many elements which go into the finished product. . . . Lighting is such an important factor that it must be considered as a basic element in the overall picture."

Student response to this yearly competition is enthusiastic as evidenced by a letter from one of the contestants, who says "The Lighting Competition has conveyed one concrete fact to me. That is the importance of teamwork between architects and engineers in the building field."

Entries were judged by the following members of the jury: Van Lee Schmidt, T. M. Abell, Maynard Lyndon and Winston Cordes, all of A.I.A.; and T. H. Shepherd, R. E. Dahlin, W. Gruen and Jerry Silvers, of I.E.S.

Edison Birthplace To Be Fund Depository

The United States National Committee of the Commission International de l'Eclairage (I.C.I.) has selected the town of Milan, Ohio, birthplace of Thomas A. Edison, as the place of deposit for the Committee's funds.

"Utilizing Milan as the Committee's depository will to some degree help keep alive the Edison tradition, and will be a recurring reminder of the debt which the electrical industry owes to its foremost pioneer," said T. D. Wakefield, Treasurer of the U. S. National Committee.

Two New Student Branches Have Charter Meetings

The University of Miami and Louisiana State University have recently held their Charter Meetings as Student Branches of I.E.S.

The group at the University of Miami, with 15 charter members including Prof. Jackson S. Seels as faculty advisor, is

(Continued on page 20A)

Section status charter is presented by Paul Hildebrand (right), Regional V-P to Maryland Section Chairman J. M. Asher (left).

(Continued from page 19A)

composed in the main of students from the School of Illuminating Engineering and the School of Architectural Engineering. The branch, with duty elected student officers, has the backing of the School of Engineering faculty, the Southeast Florida Chapter, I.E.S. and the local electrical industry.

Over in New Orleans, R. Cecil Paslay, Regional V-P, recently presented the Louisiana State University Student Branch with their Charter. Professor W. D. Morris is faculty advisor.

First Extension Meeting Held by Maryland Section

Meeting jointly with the Southern Engineering Society, the Maryland Section held its first extension meeting in Hagerstown, Md. Chairman J. M. Asher presided at the meeting which featured as speaker Ted Sargent, Chairman of the Progress Committee, I.E.S., who spoke on Lighting Progress.

A highlight of the evening was the presentation of the Section Charter to the Maryland Section (formerly Baltimore Chapter).

ABOUT PEOPLE

John B. Stirling, M.E.I.C., of Montreal has been elected president of the Engineering Institute of Canada for the year 1952-1953. He succeeds Ira P. Macnab of Halifax, N. S. Mr. Stirling took his new office during the annual meeting of the Institute which is being held in the Hotel Vancouver, Vancouver, B. C., May 7-9.

The first award of the K. C. Li Medal for meritorious achievement in advancing the science of tungsten has been made to **William David Coolidge**, vice-president and acting head of Columbia University. Dr. Coolidge's contributions made possible the use of tungsten in lamp filaments. He is director emeritus of the General Electric Research Laboratory in Schenectady, N. Y.

R. L. Biesele, Jr., of Southern Methodist University, has been appointed to the Mid-Southwest Sub-committee on Tropical Housing and Building of the Building Research Advisory Board.

A new sales district has been announced by the General Electric Co. Lamp Division and **Theodore C. Lauck** has been named manager. The new district, with headquarters at 1040 St. Charles Ave., New Orleans, La., will be known as the Delta Sales District and will encompass the southern sections of Louisiana, Mississippi, Alabama and western Florida. Mr. Lauck is an active member of the I.E.S.

E. W. Noxon, manager of Westinghouse Electric's southern lamp plants, announced the relocation of their headquarters in Little Rock, Ark. The promotion of **Frank Ments** to the position of superintendent of the Richmond plant was also announced. Mr. Mentz succeeds **C. T. Nichols**, who in turn was recently appointed manager of the division's new plant at Reform, Ala.

The Electro Mfg. Corp., Chicago, and Bright Light Reflector Co., Inc., Bridgeport, Conn., have announced the merging of their operations under the name of Electro Silva-A-King. **Charles I. Schneider** has assumed the presidency of the new company.

Samuel B. Williams has been appointed Assistant to the President of Sylvania Electric Products, Inc., with headquarters in the New York office. **George W. Griffin** succeeds Mr. Williams as Director of Public Relations.

E. C. Hugh, Sales Manager of the Frink Corp., Long Island City, New York, attended the Annual Meeting at Eastbourne, England, May 20, and on his trip visited the outstanding lighting equipment manufacturers in Great Britain.

Two new district managers have been appointed to two new districts of Sylvania Electric Products, Inc. **J. F. Davis** has been named district sales manager of the newly formed Newark District and **E. B. Colby** has been appointed manager of the Pittsburgh District. Both men are active in I.E.S. activities.

John B. O'Donnell has been appointed sales representative in charge of the recently opened Boston branch office for lighting and luminous tube transformer sales of Sola Electric Co. His headquarters will be at 246 Walnut Street, Newtonville, Boston.

Naim M. Abou-Taleb, who is currently completing the requirements for a doctorate specializing in illuminating engineering at Stanford University, will be soon teaching this subject at Farouk University in Egypt.

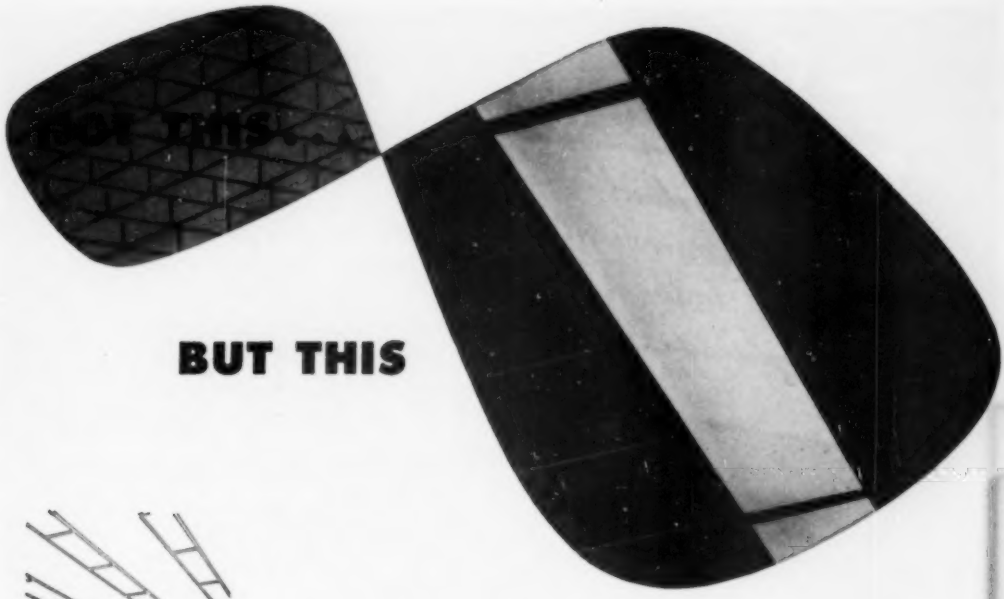
OBITUARY

Leo Hayes Cleary, who died May 3, after a brief illness, is mourned by friends and associates in the Capital Section, who miss his counsel in local Society affairs.

Mr. Cleary, well-known electrical engineering consultant, designed the lighting for the Senate and House Office Buildings, the restoration of Williamsburg, Va., did the planning of electrical systems for the Capitol power plant ,the Bureau of Standards hydraulic building, Holy Name College and the National Geographic Society administration building.

In 1944, Mr. Cleary joined the I.E.S. as a full member.

(*New Members on page 23A*)



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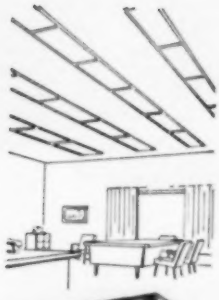

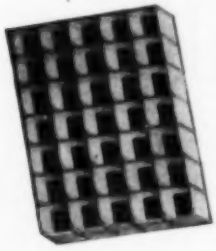

The tiny opal louvers are part of the glass itself—will not deteriorate with age or weathering—save metals—lower maintenance costs.

Corning's FOTA-LITE gives you louvered light without the "egg crate" effect

Dust-catching louvers reduce the efficiency and mar the beauty of louvered lighting installations, but with Corning's FOTA-LITE, there is no such problem. The louvers are actually part of the glass itself . . . presenting a smooth, flat surface that can be wiped clean quickly.

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FOTA-LITE is strong, light in weight, and free of warpage. It is ideal for enclosed fixtures, totally luminous ceilings . . . wherever louvered lighting *without bulk* is desired. Louvers in the standard product are accurately designed for 45° cut-off. For other applications, a wide variety of patterns can be produced in the glass.

FOTA-LITE is featured in ceiling installations and top quality luminaires by the leading manufacturers of lighting fixtures.

For complete information send for Bulletin LS-32 which describes FOTA-LITE.

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NEW MEMBERS

At the meeting of the Council Executive Committee held in Cleveland, Ohio on May 7, 1952, the following were elected to membership:

ALAMO CHAPTER

Associate Member:

Beyert, Ted, Federal Electric Products Co., San Antonio, Texas.

ARIZONA CHAPTER

Associate Members:

Arvizu, H. V., A. & B. Lighting Co., Phoenix, Ariz.
Bomar, E. B., Day-Brite Lighting, Inc., Phoenix, Ariz.
Brown, J. D., Graybar Electric Co., Phoenix, Ariz.
Davis, P. E., Luxor Lighting Products Inc., Phoenix, Ariz.
Kaplan, Al., Tucson Electric Supply Co., Tucson, Ariz.
Kaplan, I. D., Tucson Electric Supply Co., Tucson, Ariz.
Kuenta, F. P., Del E. Webb Construction Co., Phoenix, Ariz.
Logan, J. P., Phoenix Electric Supply Co., Phoenix, Ariz.
Mobley, C. L., Tucson Gas Electric Light & Power Co., Tucson, Ariz.
Osborn, W. C., Westinghouse Electric Supply Co., Phoenix, Ariz.

BRITISH COLUMBIA SECTION

Member:

Reid, Kenneth, Corp. of the City of Victoria, Victoria, Canada.

Associate Members:

Fields, C. A., Northern Electric Co., Ltd., Victoria, B. C.
Stefanice, J. S., H. D. Mainwaring & Co., Victoria, B. C.

CAPITAL SECTION

Members:

Estabrook, C. G., Anderson & Estabrook, Inc., Arlington, Va.
Friede, H. A., District of Columbia Government, Washington, D. C.

CAROLINAS CHAPTER

Member:

Biberstein, H. V., Biberstein, Bowles & Meacham, Inc., Charlotte, N. C.

Associate Member:

Jordan, R. A., General Electric Co., Greenville, S. C.

CENTRAL NEW YORK SECTION

Associate Members:

Pugliese, A. P., New York State Division of Standards & Purchase, Albany, N. Y.
Shaw, F. E., Frederic Nicholson, Consulting Engineer, Candor, N. Y.

CHICAGO SECTION

Member:

Eisendrath, B. N., Schmidt, Garden & Erikson, Chicago, Ill.

Associate Member:

Taylor, Hartley, 605 W. Park Ave., Libertyville, Ill.

CLEVELAND SECTION

Member:

Shook, R. E., The General Fireproofing Co., Youngstown, Ohio.

Associate Members:

Goplen, L. J., Holophane Co. Inc., Newark, Ohio.
Grandi, Renzo, Buiwi & Grandi S. A., Bologna, Italy.
Metrick, E. C., H. K. Ferguson Co., Cleveland, Ohio.
Shaffer, E. F., The Ohio Power Co., Newark, Ohio.
Young, W. C., Westinghouse Electric Corp., Cleveland, Ohio.

Student Member:

Schregardus, R. D., Case Institute of Technology, Cleveland, Ohio.

CONNECTICUT SECTION

Associate Members:

MacFarlane, J. M., Marchant & Mingos, West Hartford, Conn.
Mackie, W. T., Connecticut Power Co., Stamford, Conn.
Sticklor, H. R., Sticklor Electric Supply Co., Hartford, Conn.

CORNHUSKER CHAPTER

Member:

Foster, W. B., Iowa Power & Light Co., Council Bluffs, Iowa.

Associate Members:

Clapp, A. D., Bluffs Electric Fixture & Supply Co., Council Bluffs, Iowa.
Christiansen, V. G., V. G. Christiansen Sales Co., Omaha, Neb.

EASTERN PENNSYLVANIA SECTION

Associate Members:

Ludwig, R. M., Hamburg Electric, Hamburg, Pa.
Silvey, Harold, Silver Electric Supply Co., Reading, Pa.

FOREIGN NON-SECTION

Members:

Claude, Andre, Paz & Silva, Paris, France.
Knudsen, Bent, Technical University of Denmark, Copenhagen, Denmark.

Associate Members:

Gottlich, H., New Era Fluorescent Lights (Pty) Ltd., Johannesburg, So. Africa.
Tabraham, D. L., The General Electric Co., Ltd., Kingsway, London, England.

Student Member:

Singh, Harbans, London University, London, England.

GEORGIA SECTION

Member:

Minors, C. R., Georgia Power Co., Rome, Ga.

Associate Members:

Bonker, Miss Nina Faye, Georgia Power Co., Atlanta, Ga.
Minton, C. R., City of Decatur, Decatur, Ala.

HAMILTON ONTARIO CHAPTER

Associate Member:

New, F. W., Walker & Associates Ltd., Hamilton, Ont.

HEART OF AMERICA SECTION

Members:

McDonald, J. G., Graybar Electric Co. Inc., Kansas City, Mo.
Means, Jay, 3645 Main St., Kansas City, Mo.
Marvin, R. R., General Electric Co., N. Kansas City, Mo.

Associate Members:

Hess, Werner, Tiemann-Hess Electric Supply Co., Kansas City, Mo.
Jones, G. H., Automatic Temperature Control Co., Kansas City, Mo.
O'Connor, F. P., St. Joseph Light and Power Co., St. Joseph, Mo.
Smiley, A. E., Jr., A. E. Smiley & Co. Inc., Kansas City, Mo.
Smiley, Vincent, A. E. Smiley & Co. Inc., Kansas City, Mo.
Steele, Guy, Miller Light & Fixture Co., Kansas City, Mo.

IOWA SECTION

Associate Members:

Clutter, D. F., Terry-Durin Co., Cedar Rapids, Ia.
Ramsay, J. C., Edwin F. Guth Co., St. Louis, Mo.

MARITIME CHAPTER

Associate Member:

MacMackin, H. D., H. D. MacMackin & Co., St. John, N. B.

MARYLAND SECTION

Associate Members:

Doherty, J. R., James K. Wolfrod, Consulting Engineer, Baltimore, Md.
Kennard, C. E., Crouse-Hinds Co., Baltimore, Md.

MEXICO CHAPTER

Associate Members:

Domae, Armando, Iluminacion Fluorescente, Mexico, D. F.
Gameros, Sabino Escobedo, General Electric Co., Mexico City, D. F.
Perez, Jose Quinzanos, Quinzanos, S. A., Mexico, D. F.

MICHIGAN SECTION

Associate Members:

Bush, F. E., III, Ford Motor Co., Livonia, Mich.
Doyle, L. J., Sylvania Electric Products, Inc., Detroit, Mich.
Friese, J. W., Shaw Electric Co., Detroit, Mich.

MILWAUKEE SECTION

Member:

Henningfeld, D. S., Northern Light Co., Milwaukee, Wis.

Associate Members:

Dykema, W. T., Westinghouse Electric Corp., Appleton, Wis.
Toll, H. E., Westinghouse Electric Supply Corp., Milwaukee, Wis.

MONTREAL SECTION

Associate Members:

Baker, E. W., Munderloh & Co., Montreal, Que.
Vincent, Francois, Franke, Levasseur & Co. Ltd., Montreal, Que.

NEW ENGLAND SECTION

Associate Members:

Anderson, D. H., General Electric Co., Lynn, Mass.
Canning, J. F., Westinghouse Electric Corp., Belmont, Mass.
Collins, J. F., Jr., First National Stores Inc., Boston, Mass.
Merkle, R. A., General Electric Co., Lynn, Mass.
Montgomery, J. W., Mitchell Mfg. Co., Waban, Mass.
O'Donnell, J. B., Sola Electric Co., Newtonville, Mass.
Reid, R. A., General Electric Co., Lynn, Mass.

NEW ORLEANS SECTION

Member:

Haverkamp, J. D., New Orleans Public Service Inc., New Orleans, La.

Associate Member:

Songe, D. J., Jr., Freret & Wolf, New Orleans, La.

NEW YORK SECTION

Members:

Foote, F. M., National Society for the Prevention of Blindness, New York, N. Y.
Friedman, H. H., J. L. Ottenheimer, Consulting Engineer, Albany, N. Y.
Gruber, M. D., Sheldon Lighting Co., Roosevelt, N. Y.

(Continued on the next page)

(Continued from preceding page)

Lamboy, L. N., Niagara Mohawk Power Corp., Albany, N. Y.
Miller, Clifford, Consolidated Edison Co. of N. Y. Inc., New York, N. Y.
Bowman, W. S., Jr., 152 Washington Ave., Albany, N. Y.

Associate Members:

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Broadbove, H. F., State of New York, Dept. of Public Works, Albany, N. Y.
Davis, W. L., Leader Electric Co., New York, N. Y.
Helpern, W. J., Line Material Co., Albany, N. Y.
Kaufman, Melvin, Lustra Corp. of America, Brooklyn, N. Y.
Mathoffer, J. J., Burns & Roe Inc., New York, N. Y.
Palmer, C. N., General Electric Co., Albany, N. Y.
Sweeney, F. C., Graybar Electric Co. Inc., Albany, N. Y.
White, R. A., Sylvania Electric Products Inc., Buffalo, N. Y.

Northern California Section

Associate Members:

Gilbert, J. A., 260 Kearny St., San Francisco, Calif.
Moon, H. R., Westinghouse Electric Corp., Emeryville, Calif.
Stanton, H. W., Westinghouse Electric Corp., San Francisco, Calif.

Ohio Valley Section

Member:

Kristof, J. A., O. H. Bromberg & Associates, Cincinnati, Ohio.

Associate Members:

Fichiger, D. C., Dayton Power & Light Co., Dayton, Ohio.
McCluskey, V. G., General Electric Co., Cincinnati, Ohio.

Oklahoma Chapter

Member:

Whiteside, F. A., Black & West, Tulsa, Okla.

Associate Member:

Alley, J. H., Dunn Test Corp., Ada, Okla.

Philadelphia Section

Associate Members:

Daly, J. M., 201 N. Sproul Rd., Broomall, Pa.
Doll, W. H. Jr., Westinghouse Electric Supply Corp., Philadelphia, Pa.
Gallagher, T. H., Philadelphia Electric Co., Philadelphia, Pa.

Pittsburgh Section

Associate Members:

Hendrickson, D. V., V. E. Hendrickson Co., Youngstown, Ohio.
Johns, H. H., Jr., Electric League of Western Penna., Pittsburgh, Pa.

Quebec Chapter

Associate Member:

Latulippe, Edgar, Rosemont Electric Co., Quebec, Que.

Rochester Section

Associate Members:

Foreman, Joseph, 1667 Creek St., Rochester, N. Y.
Robinson, R. L., Graybar Electric Co., Rochester, N. Y.

Rocky Mountain Section

Members:

Chauvin, W. A., Chauvin Electric Co., Albuquerque, N. M.
Hotaste, E. D., The Miller Co., Meriden, Conn.
Krock, P. M., The Austin Co., Denver, Colo.

Associate Members:

Atkinson, R. G., Public Service Co. of Colo., Denver, Colo.
Busch, W. B., Pott Electric Co., Rocky Ford, Colo.
Doulin, Sally R., University of California, Los Alamos, N. M.
Garrett, R. E., Black & Veatch, Los Alamos, N. M.
Joseph, Gerald, Fluorescent Maintenance Co., Albuquerque, N. M.
Ramey, I. N., Jr., Rite Lite Supply Co., Denver, Colo.
Bivian, I. J., Everett T. Vosler Co., Denver, Colo.

St. Louis Section

Member:

Norris, J. G., Butler Electric Co. Inc., St. Louis, Mo.

Associate Members:

Gaythwaite, M. S., Sylvania Electric Products Inc., St. Louis, Mo.
Koerner, C. C., Harris-Hanson Co., St. Louis, Mo.

Southeast Florida Chapter

Associate Members:

Poor, R. L., Florida Power & Light Co., Miami Beach, Fla.
Solls, J. S., University of Miami, Miami, Fla.

Student Members:

Arpante, A. R., University of Miami, Coral Gables, Fla.
Dunn, R. T., University of Miami, Coral Gables, Fla.
Gibson, J. B., University of Miami, Coral Gables, Fla.
Hughes, J. K., University of Miami, Coral Gables, Fla.
Lefkowitz, Howard, University of Miami, Coral Gables, Fla.
McCall, H. E., University of Miami, Coral Gables, Fla.
McMillan, D. L., University of Miami, Coral Gables, Fla.
Minnet, C. J., University of Miami, Coral Gables, Fla.
Morgan, G. T., University of Miami, Coral Gables, Fla.
Newman, R. S., University of Miami, Coral Gables, Fla.
Sanders, A. W., Accessories Service Co., Miami Springs, Fla.
Weingarten, Gabriel, University of Miami, Coral Gables, Fla.
Weinkrot, Herbert, University of Miami, Coral Gables, Fla.
Zaloga, A. R., University of Miami, Coral Gables, Fla.

Southern California Section

Member:

Barrett, L. W., Sylvania Electric Products, Inc., Los Angeles, Calif.

Associate Members:

Barnett, R. W., Bowen, Rule & Bowen, Los Angeles, Calif.
Blumberg, Nat, 1334 Journey's End Drive, LaCanada, Calif.
Fite, G. C., Central Mfg. Dist., Inc., Los Angeles, Calif.
Korte, Herbert, Graybar Electric Co., Los Angeles, Calif.
Scritsmier, J. L., Sylvania Electric Products Co., Los Angeles, Calif.
Shields, D. E., Southern California Edison Co., Fullerton, Calif.
VanStan, R. W., State of California, Dept. of Public Works, Los Angeles, Calif.

Southwestern Section

Member:

Purvis, H. S., 212 E. Washington Ave., Jonesboro, Ark.

Associate Members:

Aiken, H. W., 216 S. Brighton, Dallas, Texas.
Brown, W. M., Jr., Texas Electric Service Co., Eastland, Texas.
Coker, Sam, Jr., Texas Electric Service Co., Midland, Texas.
Collins, L. M., Jr., General Electric Supply Corp., Lubbock, Texas.
McKeithen, W. G., Consolidated Vultee Aircraft Co., Ft. Worth, Texas.

Tennessee Valley Section

Student Members:

Buxton, J. A., Southern College of Optometry, Memphis, Tenn.
David, D. E., Southern College of Optometry, Memphis, Tenn.
Lorance, A. E., Jr., Southern College of Optometry, Memphis, Tenn.
Mireles, H. D., Southern College of Optometry, Memphis, Tenn.
White, H. C., Southern College of Optometry, Memphis, Tenn.

Toronto Section

Associate Members:

Cohen, E. I., Ideal Electric Ontario Ltd., Toronto, Ont.
Johnstone, Stanley, Canadian Westinghouse Co. Ltd., London, Ont.
Pithie, J. E., Pithie Electric Co., Windsor, Ont.
Stewart, Kenneth, Sylvania Electric (Canada) Ltd., Toronto, York, Ont.
Williams, H. M., Garcy Co. of Canada Ltd., Toronto, Ont.

Twin City Section

Members:

Grodin, F. A., General Electric Supply Corp., Duluth, Minn.
Pulver, R. F., Minnesota Power & Light Co., Duluth, Minn.

Associate Members:

Ahlstrom, H. W., Superior Water, Light & Power Co., Superior, Wis.
Bothwell, J. W., Kelley-How-Thomson Co., Duluth, Minn.
Cathcart, R. W., W. E. Ellingsen, 217 Torrey Bldg., Duluth, Minn.
Christopher, I., Belknap Electric Co., Superior, Wis.
Fencil, R. J., Westinghouse Electric Supply Co., Duluth, Minn.
Gunderson, T. A., Superior Water, Light & Power Co., Superior, Wis.
Gurovitsch, A. D., Northern Electric Supply Co., Duluth, Minn.
Hanson, C. W., Graybar Electric Co., Minneapolis, Minn.
Korkow, D. B., University of Minnesota, Minneapolis, Minn.
Lee, J. D., R. H. Cepples Co., Minneapolis, Minn.
Mahan, Frank, Jr., Benson Electric Co., Superior, Wis.
Mitchell, E. M., Commercial Electric Co., Duluth, Minn.
Nelson, C. G., Commercial Electric Co., Duluth, Minn.
Nelson, G. W., Graybar Electric Co., Duluth, Minn.
Nordale, J. C., Northern Electric Supply Co., Duluth, Minn.
Nyland, E. G., Nyland Electric Co., Duluth, Minn.
Olen, M. A., Thompson Electric Co., Cloquet, Minn.
Spell, H. W., Northern States Power Co., Minneapolis, Minn.
Springer, B. W., Ross Electric Co., Superior, Wis.

Western New York Section

Associate Members:

Duffy, W. R., Ferguson Electric Construction Co. Inc., Buffalo, N. Y.
Hardy, L. H., University of Buffalo, Buffalo, N. Y.

Winnipeg Chapter

Associate Members:

McDowell, A., R. A. Robinson Co. Ltd., Winnipeg, Man.
Taylor, George, Mitchell Mfg. Co., Toronto, Ont.

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Smithcraft area illumination

NOW . . . advanced design fulfills all the possibilities and benefits promised by overall lighting! Smithcraft Area Illumination is a complete fluorescent lighting system free from all the limitations and mechanical difficulties of previous attempts, yet it is not "custom built" to each installation. Skillfully engineered with unbelievable simplicity, Smithcraft Area Illumination when installed becomes a lighting "fixture" of limitless dimensions, shapes and patterns with unrestricted selection of shielding media and varied intensities within the system. For those who plan, recommend and install, here is an important new tool and business-producer; for the user, Smithcraft Area Illumination opens up exciting new possibilities for effect combined with illumination of unequalled quality.

architects

To the architect, **Smithcraft Area Illumination** presents a new opportunity for freedom of expression in the integrating of lighting interiors within interior design. Here is freedom of choice with no restrictions as to **size, pattern, intensity, shielding,** and **periphery.**

engineers

Engineers can now specify **and get** any required level of intensity. Or **different** intensities for different sections of an installation may be recommended to permit optimum usage of store or office areas. Alternating light, rows of lighting, or banks of lighting are possible because of flexibility of switching and a specially designed wiring system.

contractors

Ease and economy of installation are truly amazing! **Smithcraft Area Illumination** is actually installed in far less time than any combination of ceiling and illumination currently available. No careful dimensioning is required and no special tools, rules, or gadgets. From the time the hangers are in position on the ceiling to the finished installation, only a water level and small screwdriver are required.

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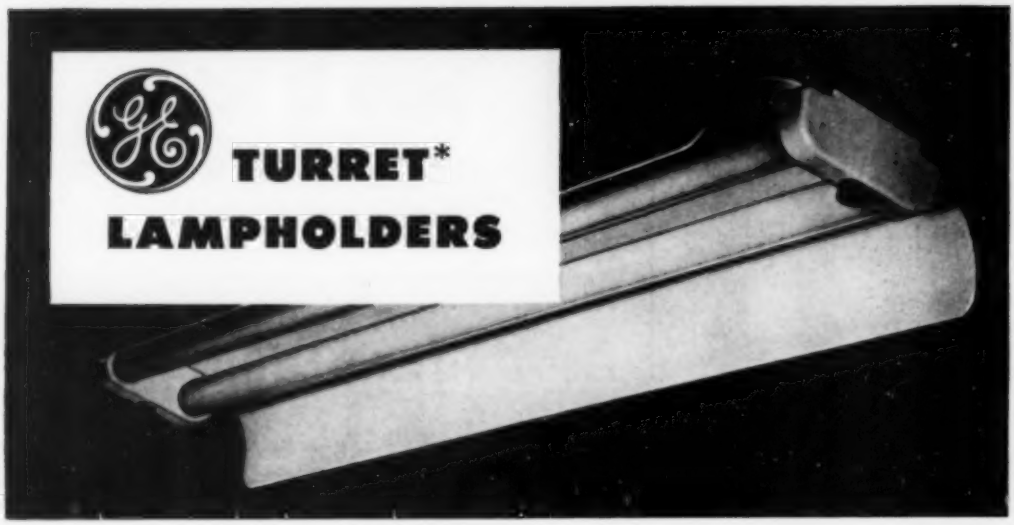
For those who own buildings and businesses of many kinds, **Smithcraft Area Illumination** is a **profitable** and practical investment. Versatile and adaptable, here is highest quality illumination combined with appearance and effect that **sells** and **produces.** Its ease of maintenance and adaptability to future plans and developments are factors that interest any businessman. Yet, its initial cost is comparable to that of a suspended ceiling and troffer system.

America's finest fluorescent fixtures **Smithcraft**
LIGHTING DIVISION
CHELSEA 50 · MASSACHUSETTS

Send now for further information on Smithcraft Area Illumination.



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1. EASY RELAMPING—To relamp G-E Turret lampholders, maintenance men simply push lamp against *either* spring-backed contact plate, slip other end in place.

2. TOUGH CONSTRUCTION—Steel Turret lampholders don't crack or break during relamping. Lamp and starter sockets take rough handling, are built for hard usage.

3. SURE GRIP—Spring-backed contact plates of Turret lampholders keep lamp pins fixed positively in position. No lamp safety-guards are required.

4. SMART, PRACTICAL SHAPE—Flush back of Turret lampholder makes neat, finished end-plate for fixture—eliminates need for extra trim. It permits mounting fixtures end-to-end for continuous lighting installations.

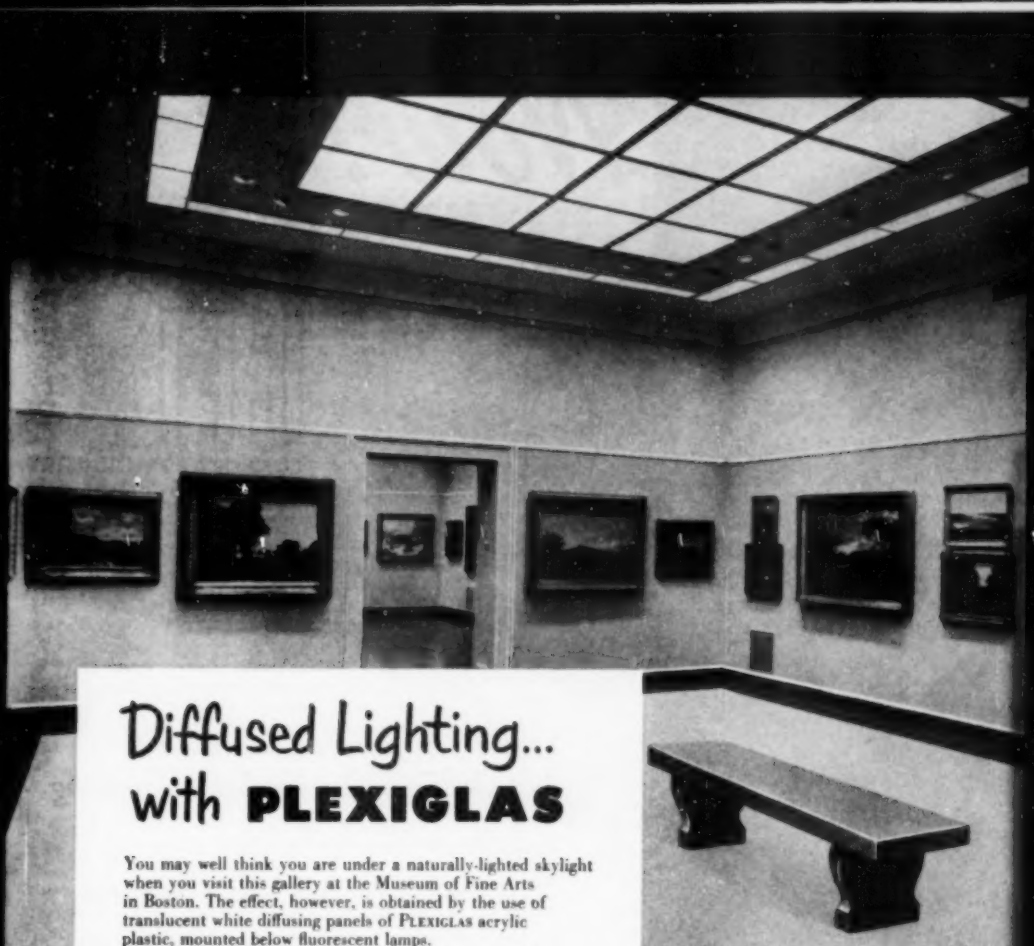
Turret lampholders offer all these features—plus the value of the General Electric name. So specify the brand in biggest demand—G-E Turret lampholders. For further data, write Section Q17-687, Construction Materials Division, General Electric Company, Bridgeport 2, Connecticut.

*Registered Trade-mark of General Electric Company

THIS SIMPLE ACTION of Turret lampholders is fast becoming a must with users of fluorescent lighting. PUSH—and the lamp depresses the spring-backed socket. TWIST—and the pins are seated. POP—and into place goes the new lamp. The entire relamping operation can be done in a matter of seconds.

You can put your confidence in—

GENERAL ELECTRIC



Diffused Lighting... with PLEXIGLAS

You may well think you are under a naturally-lighted skylight when you visit this gallery at the Museum of Fine Arts in Boston. The effect, however, is obtained by the use of translucent white diffusing panels of PLEXIGLAS acrylic plastic, mounted below fluorescent lamps.

PLEXIGLAS luminous ceilings provide high quality lighting in eight new exhibition rooms at the Museum. The totally *diffused* illumination is free of shadows and reflected glare. The effect of daylight, the most desirable condition for human vision, is achieved and the disadvantages of depending upon natural light, with its constantly shifting values, are eliminated.

The even spread of artificial light across the PLEXIGLAS surfaces and the absence of visible lighting fixtures make the luminous ceilings architecturally appealing. Higher light intensity and full color values for the paintings are supplied by directional louvers and recessed spotlights.

PLEXIGLAS luminous ceilings satisfy the requirements of architects and lighting engineers for low brightness ratios, high illumination levels, excellent diffusion, and fixture-free appearance. In addition, the lightweight yet strong diffusers are removed easily and safely for cleaning and for access to the lighting source, resulting in a sustained high level of lighting performance.

If you have a lighting problem, investigate "daylighting" with a PLEXIGLAS luminous ceiling. We will be glad to send you technical details about the installation shown above. Write for them.

Special Galleries, Museum of Fine Arts, Boston, Massachusetts. Architects: Leland and Larsen, Boston. Illuminating engineers: Thompson Engineering Company, Boston. Photograph courtesy of General Electric Company.

CHEMICALS FOR INDUSTRY

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*COMFORT FOR INDUSTRY

These scientifically designed *aperatures* make the difference—give the ideal 10% upward component of light.

. . . the first practical answer to industry's need for comfortable lighting

Number one consideration in industrial lighting has always been rugged, durable construction . . . often at the expense of comfortable illumination. But in the past Day-Brite has consistently demonstrated that highest standards of lighting and highest standards of construction can be combined.

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To give industry even more comfortable and vision-saving illumination, Day-Brite has completely redesigned its famous Day-Line industrial line. The new CFI Day-Line is *comfort* engineered to give 10% upward light distribution and put an end to the harsh brightness contrasts and dark ceilings that hamper workers.

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See the Day-Brite distributor nearest you. Get the facts about this newest advance in plant lighting. Day-Brite, Inc., 5432 Bulwer Avenue, St. Louis 7, Missouri. In Canada: Amalgamated Electric Corp., Ltd., Toronto 6, Ontario.

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IT'S EASY TO SEE WHEN IT'S

DECIDEDLY BETTER
DAY-BRITE
Lighting Fixtures

PUBLICATIONS *of the*
ILLUMINATING ENGINEERING SOCIETY

These publications summarize the studies and conclusions of technical committees of the Illuminating Engineering Society over a period of years. They contain the latest available information about many aspects of the art and science of illumination, and include details of application as well as lighting technique. Each publication listed here carries the authority and approval of the Society.

These Society publications are available in single copies for information and for lighting reference book shelves or in quantity for educational or other distribution. Each publication is numbered for ordering when using the coupon printed on the back of this page.

(1) I.E.S. LIGHTING HANDBOOK, Second Edition

BRAND NEW! One volume, 987 pages. Published 1952. Complete revision of first edition includes basic information on all phases of lighting practice and technique, based upon recently developed standards. Contains 18 technical reference and application sections; complete appendices of information regularly used; 655 photos, drawings, lighting tables, charts; fully cross-indexed . . . over 4500 items. For use of lighting engineers and specialists, consultants, architects, designers . . . all who plan, install and manufacture lighting systems and equipment.

$8.00 per copy; $6.40 in lots of ten or more. Add 50c for shipment abroad. *I.E.S. Members are entitled to one copy of the Handbook at $5.50 unless previously ordered.*

I.E.S. RECOMMENDED LIGHTING PRACTICES

These booklets contain the latest official I.E.S. lighting recommendations; illustrated with charts and photographs.

(2) HOME LIGHTING Recommended Practice (1947)

(3) OFFICE LIGHTING Recommended Practice (1947)

(4) STREET AND HIGHWAY LIGHTING American Standard Practice (1947)

(5) LIGHTING PRACTICES FOR STORES AND OTHER MERCHANDISING AREAS (1948)

(6) SCHOOL LIGHTING American Standard Practice (1948)

(7) LIBRARY LIGHTING Recommended Practice (1950)

(8) DAYLIGHTING Recommended Practice (1950)

(9) SPORTS LIGHTING Recommended Practice (1951)

Booklets above available at 50 cents per copy or in quantity as follows: first 4 copies, 50c each; next 20, 35c each; all over 24 copies, 15c each.

(10) INDUSTRIAL LIGHTING American Recommended Practice (1948)

First 10 copies, 35c each; next 40, 20c each; all over 50 copies, 15c each.

REPORTS ON LIGHTING IN INDUSTRY

Lighting recommendations based on recent studies (research, surveys of current practice, and experimental installations) of the I.E.S. Committee on Lighting Study Projects in Industry; completely illustrated. Contain analyses of seeing tasks; recommended quality and quantity of lighting; and suitable lighting methods and systems for both general and supplementary lighting.

(11) LIGHTING FOR WOOLEN AND WORSTED TEXTILE MILLS (1949)

Detailed treatment of lighting for opening and grading, carding, spinning, weaving, and perching. Data is also applicable to other types of textile mills.

(12) LIGHTING FOR MACHINING OF SMALL METAL PARTS (1949)

Analysis of factors affecting visibility of convex scales, steel rules, scribed marks, center-punch marks, concave specular surfaces, plane and convex surfaces; general shop lighting; and supplementary lighting for various measuring instruments, bench work, machine tools, and inspection of polished surfaces.

(13) LIGHTING FOR FLOUR MILLS (1949)

Close-up photos of visual tasks and levels and quality of illumination for roll, sifter and purifier floors; packing areas; and product control stations.

(14) LIGHTING FOR CANNERIES (1950)

Recommendations based on committee study and research on general supplementary artificial lighting and daylighting for tasks common to all types of canneries. Also treated are light sources and equipment suitable for installation in canneries; sanitation and safety; and adequate electrical wiring.

(15) LIGHTING FOR BAKERIES (1950)

Committee study report on baking industry; complete with photos and drawings of typical floor arrangements and lighting layouts; paint color for visual environment; use of day lighting; lighting levels for various departments; maintenance. Also use of ultraviolet.

Booklets (11) to (15) available at 50c each; quantity prices upon request.

OTHER COMMITTEE REPORTS

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Completely illustrated guide to lighting exhibits of sculpture and paintings. 50c per copy; quantity prices upon request.

(17) LIGHTING OF CENTRAL STATION PROPERTIES (1951)

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(18) TRANSPORTATION LIGHTING (1951)

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ELECTRICAL CONTRACTOR: Peterson Electric Co., New Britain, Conn.
FIXTURES: 30 Special No. F74 4-lamp fixtures.
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AVERAGE INTENSITY ON PAINTINGS, vertical plane (outside row of lamps only) 20 footcandles in service. (With all lamps on) 32 footcandles in service.

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But because they are crafted by lighting artisans . . . and made in many styles and designs . . . LITECONTROL fixtures provide installations which are "standard" in price only, definitely *custom* in appearance and performance.

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1 Folder about company's "Chieftain" line of commercial fixtures gives full details as to specifications for bi-pin and single-pin lamp fixtures and covers components and finish of the line. Gibson Manufacturing Co., Atlanta, Ga.

2 Four-page folder shows in detail the daylighting function of each of the three new PC 12" light-directing and diffusing functional glass blocks and the five PC 8" functional glass blocks. Data include recommended elevations for the use of each, description and daylighting performance. Pittsburgh Corning Corp., Pittsburgh, Pa.

3 New catalog supplement, contains eight pages describing company's line of exit and directional signs; gives general specifications for 31 types and details for ordering special carved lettering. Gruber Bros. Inc., Brooklyn, N. Y.

4 Bulletin No. 8452 announces new fluorescent horizontal continuous "T" lights for service station lighting, Series 6000, consisting of two basic 30" wide fixtures, installed separately or in series. Booklet describes color and finishes available as well as other specifications. Guardian Light Co., Oak Park, Ill.

5 Bulletin 600 lists a new line of 14 lighting specialties of this company, including fluorescent desk lamp, kitchen fixture, a portable fluorescent luminaire for various local lighting as well as others. Mitchell Manufacturing Co., Chicago, Ill.

6 Sixteen-page Bulletin 521-5 illustrates and describes newly revised transformers by this company, shows indoor and outdoor types for operation of H-1 400-watt mercury lamps. Technical data and specifications as well as installation photographs are shown. Jefferson Electric Co., Bellwood, Ill.

7 Bulletin 131 in full color describes "Vogue-Lites" made by this company for direct and indirect lighting, incorporating the universally adjustable socket feature. Luminaires are available in a variety of colors and incorporate a new mounting bracket. Swivelier Co., New York, N. Y.

8 Eight-page folder describes "Acusti-Luminus" ceilings, illustrates numerous installations, and furnishes technical data about this type of lighting job. Photos show U.L. results under fire conditions. Luminous Ceilings Inc., Chicago, Ill.

9 Bulletin describes "Dyna-Ray" spotlight for use in industrial and commercial "trouble spots" requiring a high-intensity concentrated local lighting; shows the three spot shapes available and suggests various installations. Dormitzer Electric & Mfg. Co. Inc., Cambridge, Mass.

10 Four-page brochure in color covers company's complete line of exit lighting units, edge-lighted or with directional globes as well as vapor-type lighting units. McPhilben Mfg. Co., Brooklyn, N. Y.

11 48-page booklet entitled "Facts About Cold Cathode for School Lighting" covers briefly development of this type of lighting and then describes installation data from school lighting in Detroit, Mich. Shows various types of cold cathode fixtures. Illuminating Engineering Co., Hazel Park, Mich.

12 68-page catalog No. 52 shows this company's complete line of luminaires for commercial, industrial and institutional installations, including fluorescent, slimline and incandescent; gives lighting data, typical curves and coefficients of utilization as well as installation information. The Kayline Co., Cleveland, Ohio.

13 Bulletin D851N details advantages of company's line of standard non-interlocking type of light dimmers, and contains photographs, circuit diagrams, outline dimensions and descriptive material on manual and motor-driven assemblies. Selection chart provides specific information on each type. Superior Electric Co., Bristol, Conn.

14 Eight-page 51-28K in color shows "Silver-spot" and "Silver-dot" recessed incandescent downlights. Folder gives illumination data, installation and suggests various commercial and residential applications. Skylike Lighting, Inc., New York, N. Y.

15 Bulletin describes and illustrates mercury plunger remote control relays especially for street lighting. Standard 30 amp. relays mounted in weatherproof housing may be had in a variety of types and for either normally open or closed pilot circuits. Also contains complete specifications. H-B Instrument Co., Philadelphia, Pa.

16 "War on Waste" file folder contains data needed to apply planned cleaning program and two group replacement plans for fluorescent and incandescent lamps. Program equips maintenance men with engineered scale for determining proper cleaning cycles to increase lighting equipment efficiency. Champion Lamp Works, Lynn, Mass.

17 Eighteen-page booklet B-5428 on airport lighting equipment selection and electrical requirements also presents several typical wiring diagrams for runways and taxiways, suggests applications and accessory apparatus if needed. Westinghouse Electric Corp., Pittsburgh, Pa.

18 Bulletin covers company's new 2450 recessed incandescent downlight, gives specifications on installation and suggests various applications in hospitals, stores and other locations. Pittsburgh Reflector Co., Pittsburgh, Pa.

19 New two-color 36-page catalog illustrates company's various types of fluorescent and incandescent luminaires for commercial, industrial and other installations; gives complete specifications including lighting curves and coefficients of utilization for each model. Also shows luminous ceiling. Leader Electric Co., Chicago, Ill.

20 Small fluorescent fixtures called "Lite-Mite" for use where high-intensity fluorescent localized lighting is specified are covered in new catalog showing several types and suggesting various applications in industrial and laboratory fields. Stocker & Yale, Inc., Marblehead, Mass.

21 Home lighting is the subject of a new 20-page booklet entitled "A Method for Predicting General Lighting Levels in the Home." Booklet gives a non-technical discussion of lumen method and how it can be used by home lighting specialists; includes suggested on-the-job worksheet form. Westinghouse Electric Corp., Lamp Div., Bloomfield, N. J.

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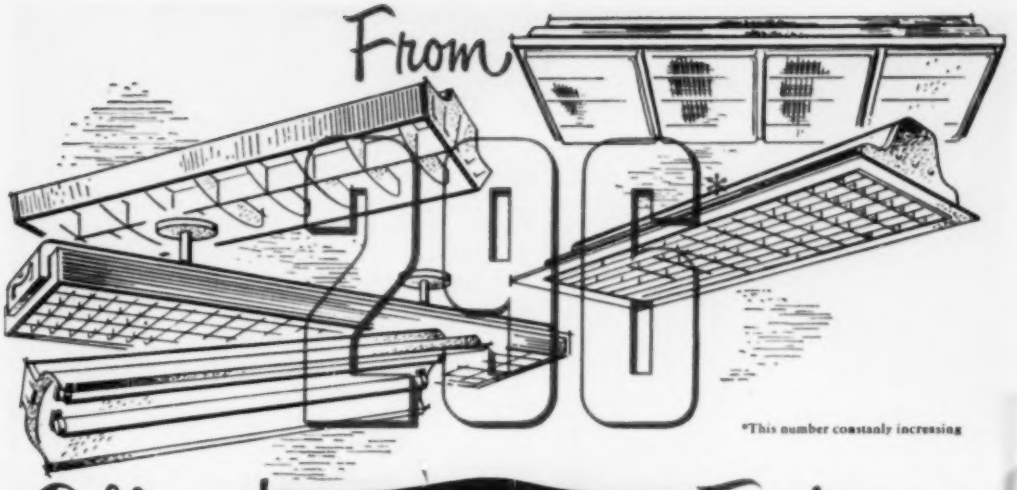

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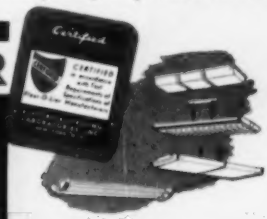

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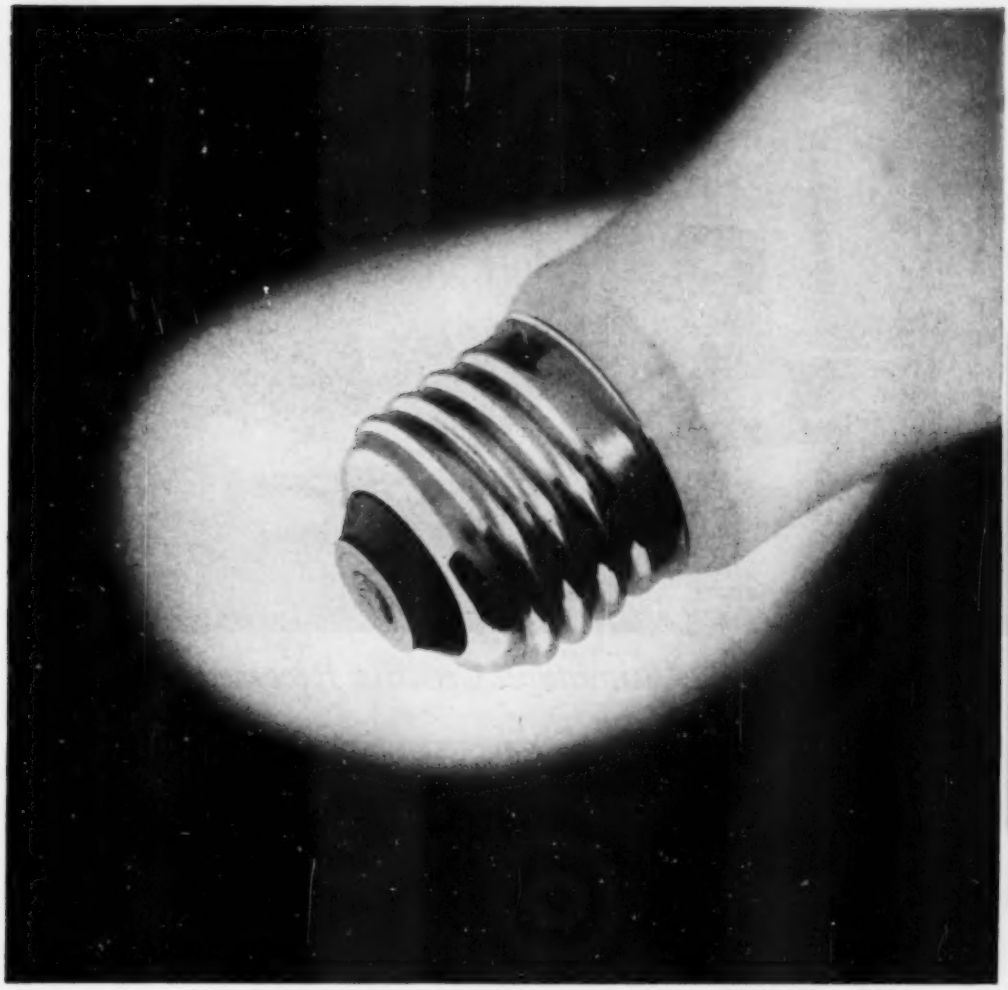

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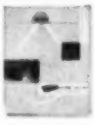

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2 Leads stapled to core for positive strain relief	YES	NO	NO
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5 Hot-dipped galvanizing on all outdoor types	YES	NO	NO
6 Deep Drawn cases on all outdoor types	YES	NO	NO
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8 Universal Pole-Top Adapter for 2½-4" O.D. Poles (a stock reducing feature)	YES	NO	NO
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SUNBEAM LIGHTING COMPANY
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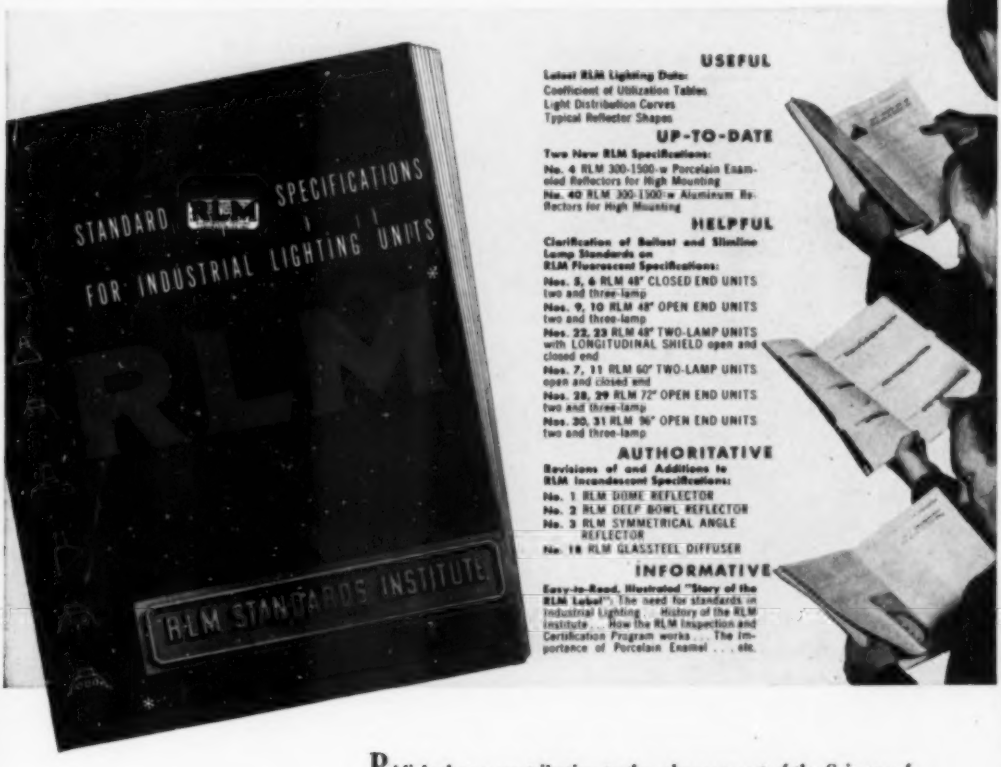
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